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# INTERPRETATION OF SUSPENDED SEDIMENT CHARACTERISTICS, RED RIVER AT EMERSON, MANITOBA, 1978-1986

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# INTERPRETATION OF SUSPENDED SEDIMENT CHARACTERISTICS, RED RIVER AT EMERSON, MANITOBA, 1978-1986

by

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## Abstract

*There is a growing awareness that fine suspended sediments are a prime media for the transport and storage of many contaminants. Within the Inland Waters Directorate, Water Quality and Water Resources Branches have responsibilities for monitoring contaminants and suspended sediments respectively. This report, which provides a summary and interpretation of existing suspended sediment data, is the first of several planned for the Red River at Emerson, Manitoba. Sampling strategies, methodologies, equipment, computational procedures and data have been evaluated with the objective of determining how the two Branches can work more effectively together.*

*Meaningful suspended sediment monitoring at Emerson, Manitoba on the Red River began in 1978 with both Water Survey of Canada (WSC) and the United States Geological Survey (USGS) initiating sampling programs. The WSC program provides data on a flow-weighted basis, year round, while the USGS program collects monthly samples only. Earlier, Prairie Farm Rehabilitation Administration sampled suspended sediments during open water in 1956 and 1961.*

*Based upon WSC data, the mean annual suspended sediment load is 886 000 tonnes for the period 1978-1986, when the mean annual flow was 39.5% higher than the historical average. The annual distribution of load is not typical as 40% of the suspended load is transported during*

*the June to August period. A general counter-clockwise hysteresis exists in the concentration-discharge relationships which arises from the high summer concentrations.*

*Suspended sediments are silt and clay which result in quite homogeneous concentrations and particle sizes in the measurement cross sections. The bed and bank materials are of similar composition.*

*Finally, data collected by WSC and USGS are shown to be quite compatible and that the two data sets can be used interchangeably. Recommendations regarding the sampling program are put forth which will aid subsequent analyses.*

## Résumé

*On prend de plus en plus conscience que les fines particules des sédiments en suspension constituent l'un des principaux moyens de transport et de stockage de nombreux contaminants. La Direction de la qualité des eaux et celle des ressources en eau, au sein de la Direction générale des eaux intérieures, sont chargées respectivement de surveiller les contaminants et les sédiments en suspension. Le présent rapport, qui résume les données disponibles au sujet des sédiments en suspension et en fait l'interprétation, constitue le premier d'une série prévue pour la rivière Rouge à Emerson, au Manitoba. On y évalue les stratégies, les méthodes et le matériel d'échantillonnage ainsi que les méthodes de calcul et les données afin d'établir comment les deux directions peuvent mieux collaborer dans leur travail.*

*Une surveillance significative des sédiments en suspension à Emerson (Manitoba), sur la rivière Rouge, a débuté en 1978 alors que les Relevés hydrologiques du Canada (RHC) et le United States Geological Survey (USGS) y ont tous deux entrepris un programme d'échantillonnage. Le programme des RHC fournit des données pondérées en fonction du débit, tout au long de l'année, tandis que celui de l'USGS prévoit seulement le prélèvement mensuel d'échantillons. Auparavant, l'Administration du rétablissement agricole des Prairies a échantillonné les sédiments en suspension durant les périodes d'eaux libres en 1956 et 1961.*

*Calculé à partir des données des RHC, le transport annuel moyen des sédiments en suspension entre 1978 et 1986 est de 886 000 tonnes, tandis que le débit annuel moyen était de 39,5 % de plus que la moyenne historique. La distribution annuelle du transport n'est pas caractéristique,car 40 % des matières en suspension sont transportées de juin à août. Une hystérésis générale dans le sens indirect est observée dans la relation entre la concentration et le débit qui est causée par les fortes concentrations enregistrées durant l'été.*

*Les sédiments en suspension se composent de limon et d'argile d'où la concentration et la granulométrie assez homogènes dans les sections mouillées servant au prélèvement des échantillons. Les matériaux du lit et du rivage sont d'une composition semblable.*

*Enfin, les données recueillies par les RHC et le USGS sont assez compatibles, et les deux ensembles de données peuvent être utilisés de façon interchangeable.*

*Les recommandations formulées au sujet du programme d'échantillonnage faciliteront les analyses ultérieures.*

## Acknowledgments

Thanks are extended to J. Way of the Water Resources Branch, Winnipeg for providing details of the history and operation of the Water Survey of Canada sediment monitoring program on the Red River and for reviewing a draft of the report. Thanks are due to G. Ryan, Water Resources Division, United States Geological Survey, for reviewing the report and providing details on their sampling program. Comments received by C. Bowden, V. Chacko, R. Hale, D. Hanson, S. Lokits, E. Ongley, R.S. Parker and F. Penner were also greatly appreciated.

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# 1. Introduction

## 1.1 Report Objectives

A major issue facing water quantity and water quality monitoring programs is the transportation of adsorbed contaminants on suspended sediments. Both the Water Resources Branch (WRB) and the Water Quality Branch (WQB) of the Inland Waters Directorate are interested in becoming more aware of how their monitoring activities are interrelated and using this information to assist in providing a more complete understanding of the source, pathway and fate of contaminated sediments. Implementation of effective future monitoring and management strategies clearly depend upon such an understanding.

Towards this goal the Red River at Emerson hydrometric station was selected as an appropriate site to develop a more integrated strategy. This particular site was chosen because it was common to both programs, it had a fairly extensive data base and it is one of the few sites in the province where sediment is being focussed upon (large samples are being collected by centrifuging) as a transporter of contaminants (Yuzyk, 1986).

Water Survey of Canada has collected hydrometric data at this site since 1912. This extensive record was important in helping to evaluate the 'hydrologic' representativeness of the shorter period when

sediment and water quality sampling was conducted. The Water Quality Branch has been collecting data since 1960 while sediment data have been collected by Water Survey of Canada continuously since 1978.

This report summarizes and provides basic interpretation of all existing suspended sediment and bed material data. This report will provide necessary knowledge of the suspended sediment regime and measure present success in its characterization. A second report is planned to provide a comparison between the suspended sediment data collected by WSC and non-filterable residue (NFR) data collected by the WQB. Later studies comparing contaminant loadings based on WSC and WQB sampling methodologies are planned. Other studies comparing sampling strategies and equipment are expected as well.

The specific objectives for this report are:

i) Compile and analyse the existing Water Survey of Canada (WSC) sediment data for the Red River at Emerson, Manitoba.

ii) Since the United States Geological Survey (USGS) also collects sediment data at Emerson, this report will address the question of compatibility of the two data bases.

iii) Finally, recommendations will be made concerning future sampling at the Emerson station.

## 1.2 Scope of Report

The last section in Chapter 1, states the purpose of both the USGS and WSC sediment programs. In Chapter 2, brief descriptions of the Red River at Emerson station and the Red River basin are presented.

Types of data, equipment, procedures and sampling strategies for both the USGS and WSC programs are discussed in Chapter 3. The question of data compatibility is also addressed in this chapter.

Although, there are two sets of suspended sediment data for the Red River at Emerson, only the WSC data set will be analysed in Chapter 4. Bed material data will also be analysed in this chapter.

Finally, the report culminates in Chapter 5 with an assessment of the data and recommendations concerning future sampling.

## 1.3 History and Purpose of Sediment Monitoring Program

### 1.3.1 Water Survey of Canada

The sediment survey program operated on a seasonal basis in the spring of 1956 and 1961. Then in 1978, the program was started on a continuous year round basis. This was a result of two factors. First, there was concern that the Garrison Diversion project in North Dakota would change the quality of rivers such as the Souris and the Red. These

rivers flow from North Dakota into Manitoba, crossing the United States-Canada border. Hence, these waters are subject to the terms of the Boundary Waters Treaty of 1909, agreed to by the USA and Canada. Water Survey of Canada therefore established a sediment monitoring program at Emerson in order to provide data required to assess possible environmental impacts arising from the Garrison project.

Secondly, it was determined that sufficient data have been collected at the Red River near Ste. Agathe station and that these resources could be moved to the Emerson site.

### 1.3.2 United States Geological Survey

The sediment program was started in conjunction with a water quality program in 1978. This station forms a part of the National Stream Quality Accounting Network (NASQAN) of the USA. The objectives of NASQAN are: (1) to obtain information on the quality and quantity of water moving within and from the United States through a systematic and uniform process of data collection, summarization, analysis, and reporting; (2) to aid in the description of the areal variability of water quality in the Nation's rivers; (3) to detect changes or trends with time in the pattern of occurrence of water-quality characteristics; and, (4) to provide a nationally consistent data base useful for water-quality assessment and hydrologic research (Harkness, R.E., Haffield, N.D., Ryan, G.L., 1987, Water Resources Data, North Dakota, Water Year 1986: U.S. Geological Survey Water-Data Report ND-86-1, p. 11).

## 2. Background

### 2.1 Hydrometric Station Description

The Red River at Emerson gauging station is located 1.2 km north of the international border between Canada and the USA. This hydrometric station has been designated as an international gauging station and is jointly operated by both WSC and USGS. The surface water data collected is jointly approved and published by both agencies. However, the sediment sampling programs of each agency are independent of each other.

The station consists of a cast in place concrete bank installation located 460 m downstream of the CNR bridge on the east bank. A Leupold & Stevens A-71 analogue float-operated recorder is used to measure river water levels. Two telemetry systems are installed to provide instantaneous data. One system is a landline Leupold & Stevens T4 telemark and the other is a Bristel Hydromet data collection platform. This equipment is housed in a concrete shelter located at the site.

The cross section of the channel is relatively stable, however due to the small hydraulic gradient there is a loop rating effect. Hence, a normal stage-discharge relationship cannot be established. This is due to the fact that for a given stage there is a greater flow on the rising limb than on the falling limb. To compensate for this phenomenon, a dynamic routing program is used to determine flows by inputting stages

and other relevant data. The mean top of bank width at this station is 180 m. The water depth varies with discharge and can be as high as 15 m.

## 2.2 Basin Description

The Red River basin has a drainage area of approximately 287 000 $km^2$. However, if the Assiniboine watershed is excluded, the Red River basin only has a drainage area of 124 000 $km^2$ as shown by Figure 1. Upstream of Emerson, the basin has a drainage area of 104 000 $km^2$.

The Red River basin is characterized as being very flat and having an elliptical shape with the long axis oriented in a north-south direction. Its length is 560 km and the basin has a width of roughly 300 km. The flow of the Red River is northerly with its tributaries generally flowing east or west.

The Red River watershed was formed during the later stages of the Wisconsin glaciation period (McLaurin and Wedel, 1981). During the retreat of the last glaciers, Lake Agassiz was formed over much of the present day basin. During the 3000 years that the lake existed a thick layer of lacustrine clay was deposited. This clay makes up the predominant soil type of the Red River basin. The low permeability of the soil combined with the extreme flatness leads to the common occurrence of marsh land in the basin.

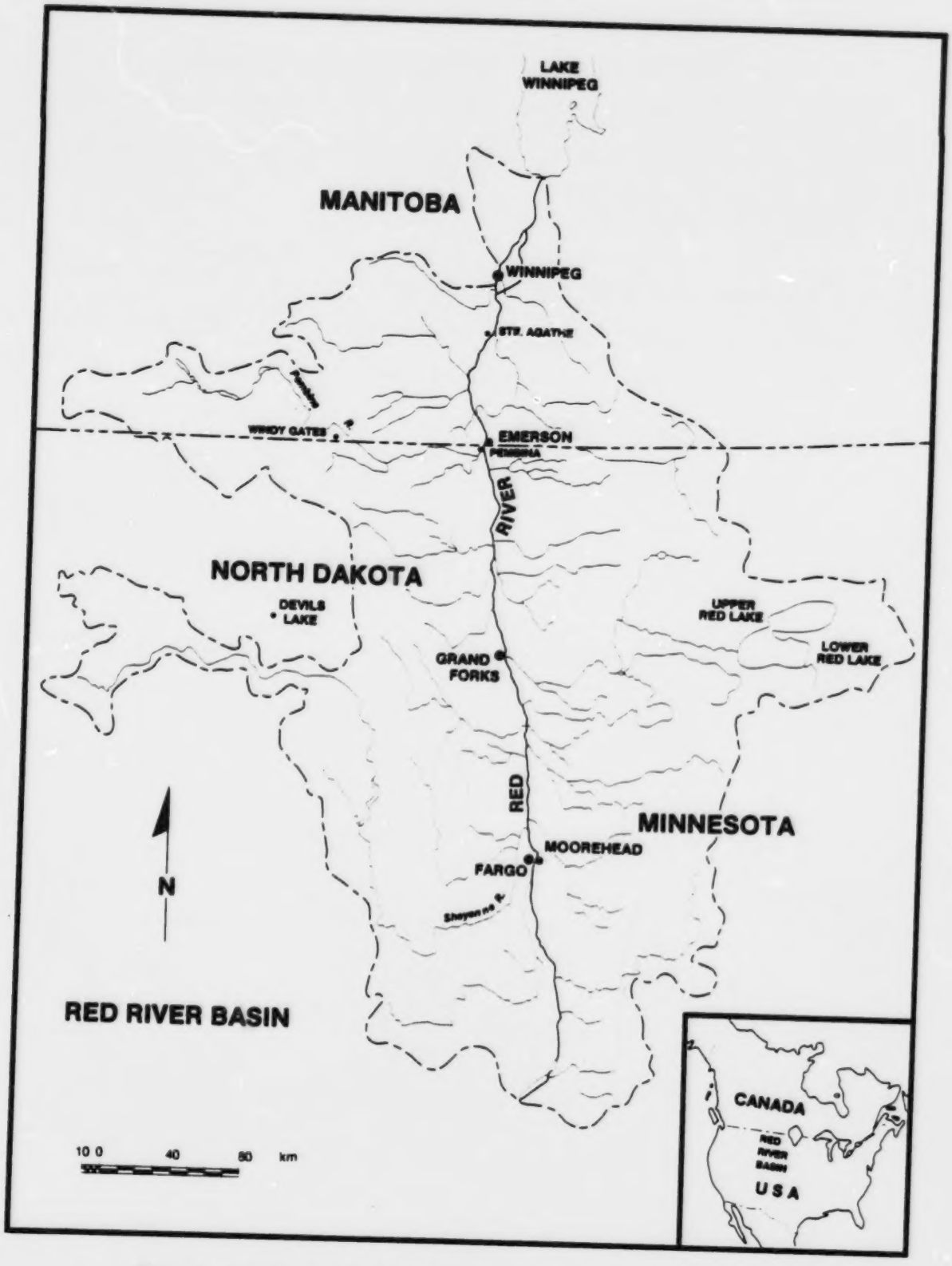



**Figure 1. Location and Drainage Basin Map of the Red River at Emerson (050C001) Hydrometric Station**

The Red River has an average hydraulic gradient of 0.0001. This combined with a cohesive soil has led to a river with a sinuosity of 2. The Red River channel, like its tributaries, is not capable of handling flood flows.

The annual mean total precipitation for the basin is 500 mm. Events occur every month, with the summer monthly means being almost twice those of winter means. Usually, winter snows remain to contribute to spring run-off. In general, summertime precipitation is not capable of keeping pace with evapotranspiration hence, most of the annual runoff occurs in the spring.

## 3. Suspended Sediment Programs

### 3.1 Water Survey of Canada Program

#### 3.1.1 WSC Types of Data

The available WSC data for the Red River at Emerson consists of the following:

I) Suspended sediment concentrations of depth integrated samples.

II) Suspended sediment loads.

III) Particle size of depth integrated suspended sediment samples.

IV) Particle size analysis of bed material samples.

V) Dissolved solids concentrations.

VI) Water temperature at time of sampling.

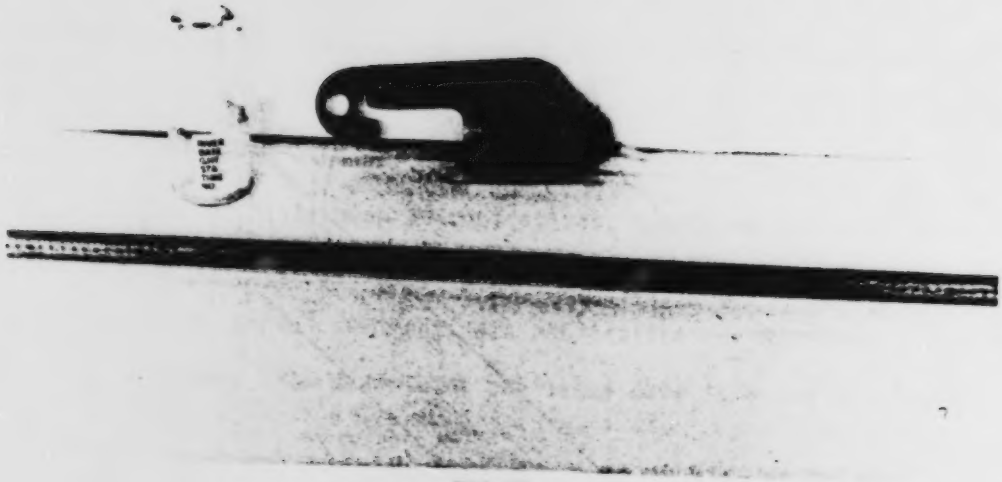
#### 3.1.2 WSC Equipment and Procedures

Most of the depth integrated suspended sediment samples were taken by an observer using a DH-59 sampler. This was supplemented by periodic

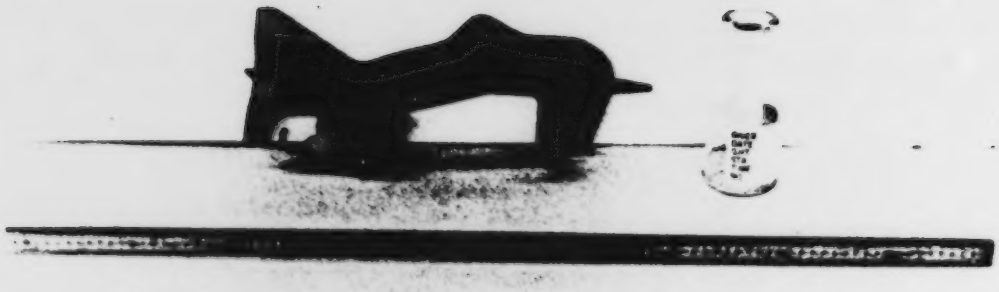
visits from a WSC technician who also collected samples using a DH-59 sampler. Occasionally a DH-48 and a D-74 sampler have been used. Both th DH-59 and DH-48 samplers are illustrated in Figure 2. Limited data have also been collected using a P-61.

Prior to 1983, single vertical samples and measurements were taken from one of three possible locations. Figure 3 illustrates these locations. During low stages, sampling was done using a cableway located just upstream of the recorder well. During high stages, when access to the cableway was submerged, sampling was done from the downstream side of HWY 75 bridge. Finally, during exceptionally high stages, when access to the HWY 75 bridge was flooded, sampling was done from the downstream side of the CNR bridge. However, since 1984, all sampling have been done from HWY 75 bridge, since access to the bridge was raised.

The method of sample collection has been the single vertical depth integrated method. Since 1984, the single sampling vertical has been referenced as a chainage point of 132 m from the right bank on HWY 75 bridge. This is a point in the cross section where: unnatural turbulence does not exist; there is always flow; and, the coefficient relating concentration at this point to the average concentration in the cross section is equal or nearly equal to one. This coefficient is called the K-factor. This type of sampling requires periodic Equal Discharge Increment sampling (EDI's) in order to determine the average concentration in the cross section. EDI sampling is done more often during periods of rapidly changing flow than for stable flows.



DH-48



DH-59

**Figure 2.** **Depth Integrated Suspended Sediment Samplers (DH-48 & DH-59)**

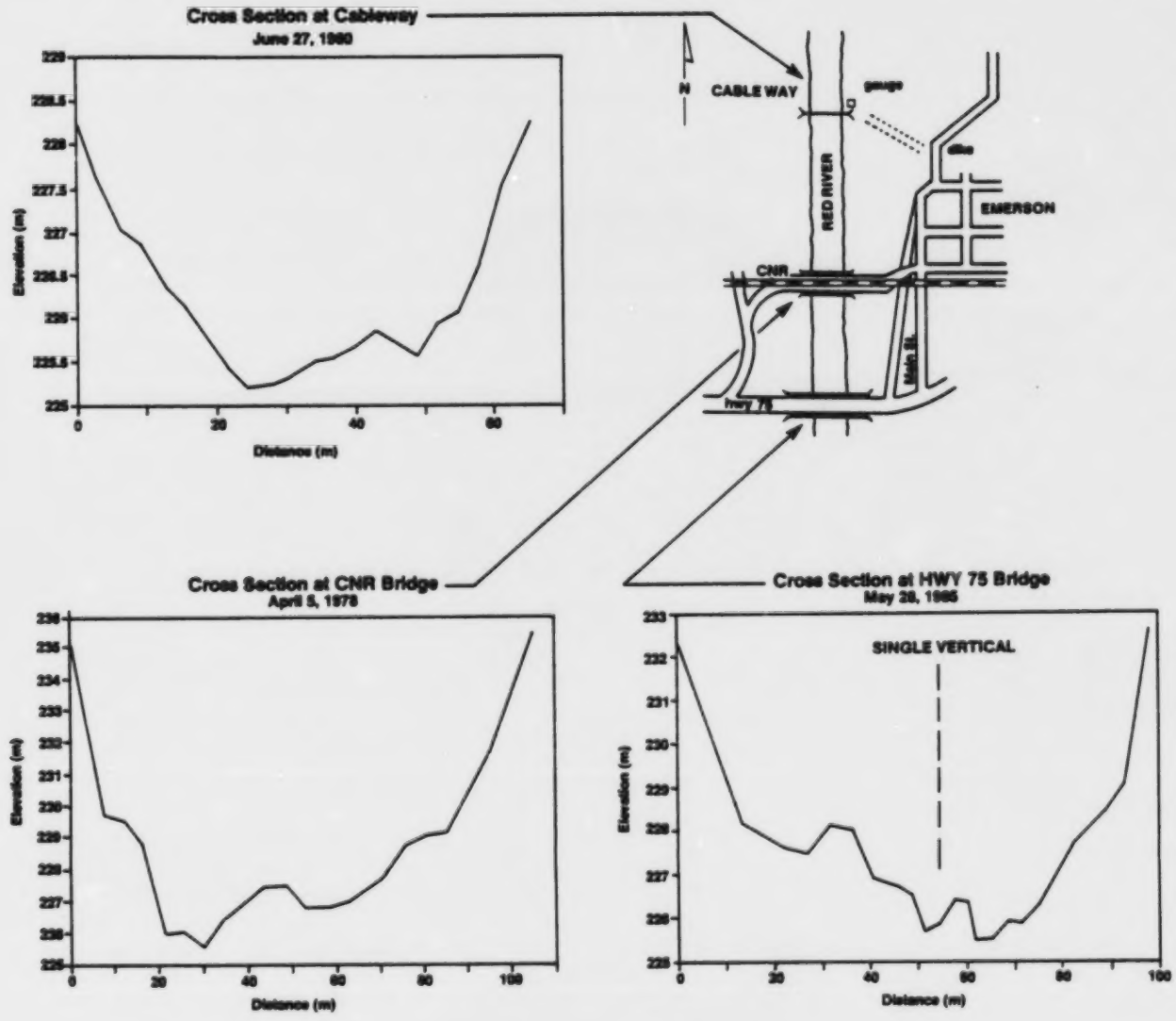



**Figure 3. Plan of the Town of Emerson, Indicating the Location and Cross Section of Each of the Three Possible Sampling Sites**

The EDI method requires that a cross section be divided into five panels, each representing approximately 20% of the flow (Environment Canada, 1987). Two samples are taken at the center of each panel and from the samples the average concentration and particle-size distribution in the cross section can be determined.

Calculated daily mean concentrations, suspended sediment loads, particle size analyses of bed material and of suspended sediments are contained in the annual sediment data publication for Manitoba, issued by Environment Canada. An example of published data is given in Appendix A.

### 3.1.3 WSC Sampling Strategies

Tables 1 and 2 show the number of days in each month when sample concentrations were collected and the percent each month's sample coverage represents of the yearly total program, respectively. In 1956 and 1961, samples were collected during April and May. From 1978 through 1986 data were collected on a continuous yearly basis. The sampling effort was concentrated during the April to June period, when spring run-off occurs, with the sampling frequency remaining high until October. This was done in order to sample the high flow events occurring during the open water season.

Figure 4 illustrates the sampling strategy for the WSC program. This figure shows that 71% of the samples, were collected during flows greater than 70 $m^3/s$ which occur about 30% of the time.

Table 1. Summary of WSC Suspended Sediment Sampling Program, Showing the Number of Sample Days Each Month.

| | NUMBER OF SAMPLED DAYS IN MONTH | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | J | F | M | A | M | J | J | A | S | O | N | D | TOTAL |
| 1956 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| 1961 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 1978 | 0 | 1 | 2 | 22 | 15 | 11 | 12 | 7 | 7 | 0 | 2 | 1 | 80 |
| 1979 | 2 | 0 | 1 | 3 | 20 | 19 | 7 | 5 | 6 | 2 | 0 | 0 | 65 |
| 1980 | 1 | 1 | 1 | 7 | 15 | 4 | 1 | 1 | 3 | 6 | 4 | 1 | 45 |
| 1981 | 1 | 2 | 2 | 8 | 23 | 16 | 7 | 3 | 2 | 5 | 1 | 1 | 71 |
| 1982 | 2 | 2 | 2 | 15 | 18 | 27 | 20 | 26 | 30 | 30 | 6 | 0 | 178 |
| 1983 | 1 | 1 | 3 | 23 | 30 | 14 | 7 | 12 | 14 | 15 | 3 | 1 | 124 |
| 1984 | 1 | 1 | 1 | 17 | 15 | 24 | 13 | 10 | 7 | 0 | 1 | 1 | 91 |
| 1985 | 1 | 2 | 3 | 8 | 13 | 1 | 21 | 21 | 30 | 31 | 11 | 1 | 143 |
| 1986 | 1 | 1 | 2 | 28 | 31 | 30 | 30 | 16 | 16 | 15 | 4 | 0 | 174 |
| | | | | | | | | | | | | | 980 |

Table 2. Summary of WSC Suspended Sediment Sampling Program, Showing the Percent Each Month's Sample Coverage Represents of the Yearly Total Program.

| | MONTHLY % OF YEARLY TOTAL | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | J | F | M | A | M | J | J | A | S | O | N | D |
| 1956 | 0 | 0 | 0 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1961 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1978 | 0 | 1 | 3 | 28 | 19 | 14 | 15 | 9 | 9 | 0 | 3 | 1 |
| 1979 | 3 | 0 | 2 | 5 | 31 | 29 | 11 | 8 | 9 | 3 | 0 | 0 |
| 1980 | 2 | 2 | 2 | 16 | 33 | 9 | 2 | 2 | 7 | 13 | 9 | 2 |
| 1981 | 1 | 3 | 3 | 11 | 32 | 23 | 10 | 4 | 3 | 7 | 1 | 1 |
| 1982 | 1 | 1 | 1 | 8 | 10 | 15 | 11 | 15 | 17 | 17 | 3 | 0 |
| 1983 | 1 | 1 | 2 | 19 | 24 | 11 | 6 | 10 | 11 | 12 | 2 | 1 |
| 1984 | 1 | 1 | 1 | 19 | 16 | 26 | 14 | 11 | 8 | 0 | 1 | 1 |
| 1985 | 1 | 1 | 2 | 6 | 9 | 1 | 15 | 15 | 21 | 22 | 8 | 1 |
| 1986 | 1 | 1 | 1 | 16 | 18 | 17 | 17 | 9 | 9 | 9 | 2 | 0 |

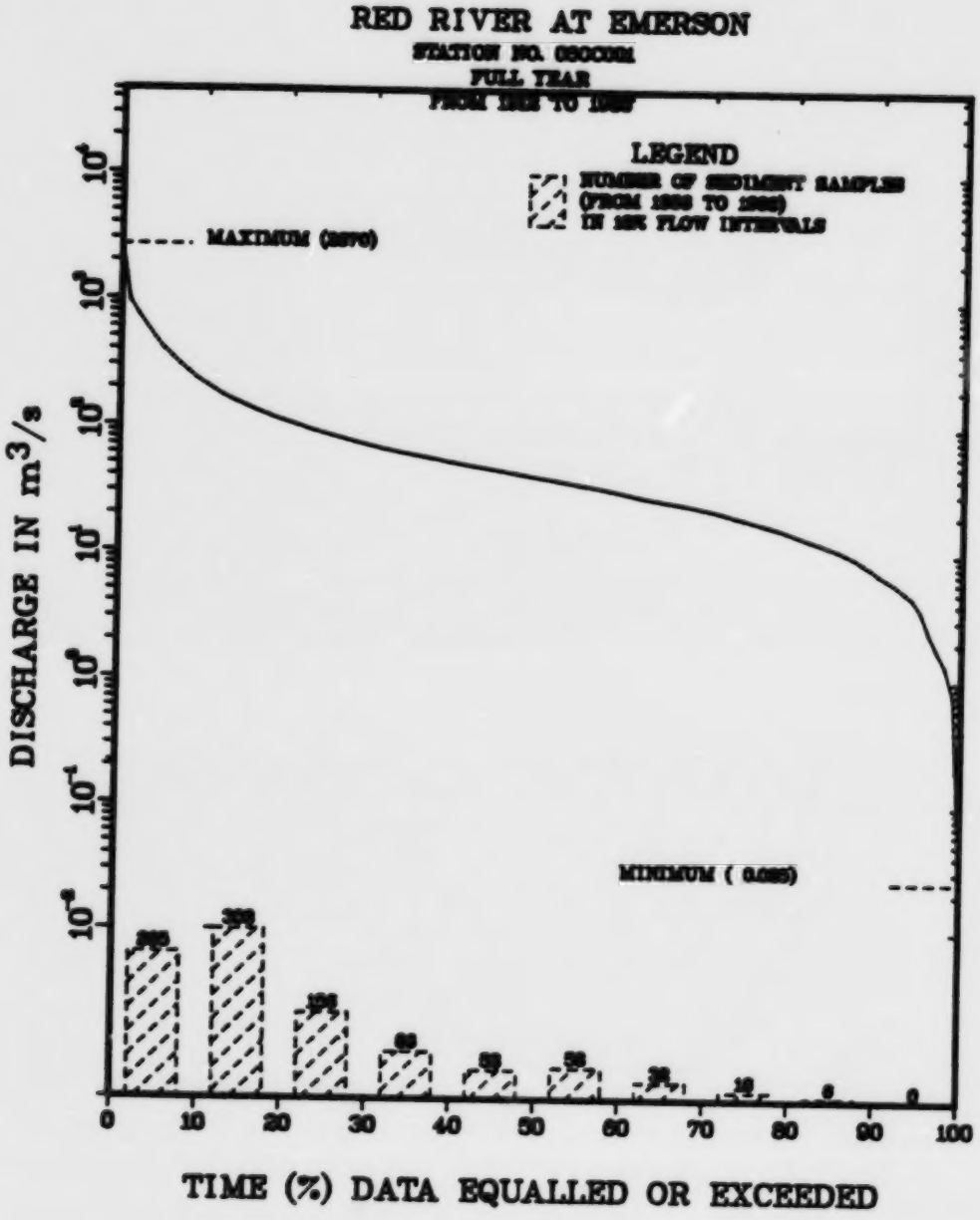



Figure 4. Flow Duration Diagram for Daily Mean Discharges from 1912 to 1986. Number of WSC Suspended Sediment Samples Collected from 1956 to 1986 in 10% Flow Intervals

## 3.2 United States Geological Survey Program

### 3.2.1 USGS Types of Data

The available USGS data for Red River at Emerson consists of the following:

I) Suspended sediment concentrations of depth integrated samples.

II) Particle size of depth integrated suspended sediment samples.

III) Dissolved solids concentrations.

IV) Water temperature.

### 3.2.2 USGS Equipment and Procedure

Suspended sediment samples are taken by a technician using a D-74 sampler, shown in Figure 5, and occasionally with a DH-59 sampler from the downstream side of HWY 75 bridge. Nozzle sizes are 0.32 cm, 0.48 cm or 0.64 cm diameter and their usage depends on the velocity and depth of water.

Sample collection was by the Equal Width Increment method (EWI). In the EWI method, the cross section is divided into a number of

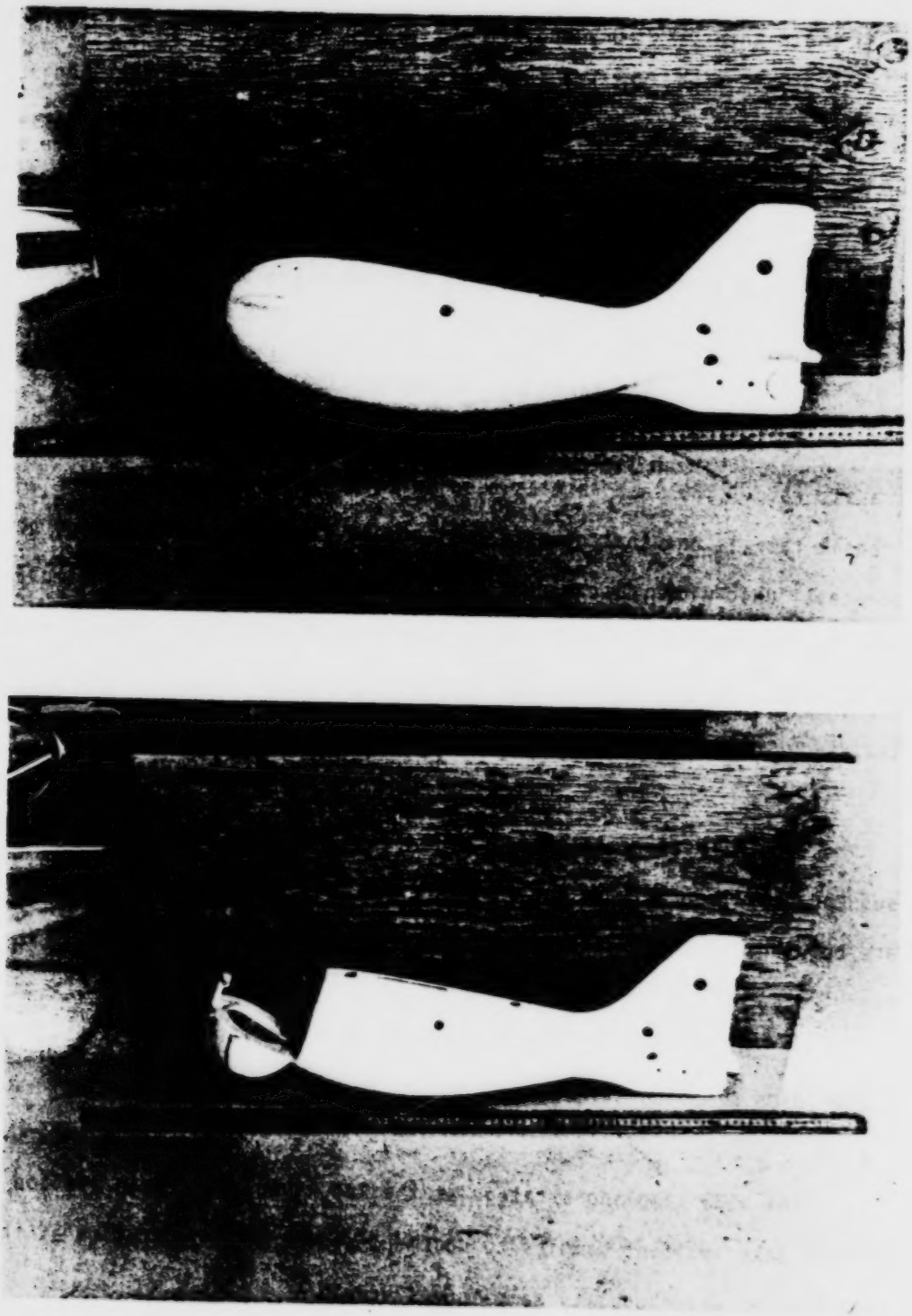


**Figure 5. Depth Integrated Suspended Sediment Sampler (D-74)**

equal width intervals (Guy and Norman, 1970). The number of intervals is usually determined from the size of the interval that represents ten percent of the flow at the part of the cross section where the "unit-width discharge" is the highest. This interval size is then used for the entire cross section and as a result it governs the number of intervals used.

Samples are then taken at the center of each interval. The sampler is lowered and raised through each sampling vertical at a uniform transit rate. The same rate is used in each vertical. The proper transit rate is one that gives a full bottle at the vertical having the greatest "unit width discharge". More than one vertical can be sampled with one bottle, so in most cases a bottle will be filled. When the entire cross section is sampled, all the bottles are combined and analysed.

Two EWI measurements are taken everytime a USGS technician samples suspended sediment at the Red River at Emerson. These two measurements are both analysed for concentration and an average concentration is reported.

### 3.2.3 USGS Sampling Strategies

The USGS sampling strategy at the Red River at Emerson station has been to take sediment samples to document sediment concentration at the same time as water quality sampling is done.

Table 3 shows the number of days in each month when sample concentrations were collected. From 1978 to 1986, data were not collected on a flow weighted basis. Most of the 62 samples were collected during moderate flows. This fact is illustrated by Figure 6, which shows that 35% of the samples were collected during flows greater than 70 $m^3/s$. WSC collected 71% of their samples above this flow.

## 3.3 Completeness of the Sediment Record

To properly document the sediment regime a sampling program should meet the following criteria:

(i) The sampling period should consist of enough years that the full range of discharges are covered.

(ii) The full range of flows within individual years should be sampled, especially the freshet peak.

Figure 7 shows that the annual maximum flows for the period 1978-1986, when both USGS and WSC programs operated, are representative of the historic range of annual maximum flows (1912-1986). However, Figure 8 shows that the total annual flows for the same period, are generally only representative of the mid to high range of the historic total annual flows.

Concerning the need to document within year variations the WSC programs, following a flow weighted sampling strategy, are quite successful. This strategy results in good coverage during the spring

Table 3. Summary of USGS Suspended Sediment Sampling Program, Showing the Number of Sample Days Each Month.

| | NUMBER OF SAMPLES PER MONTH | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | J | F | M | A | M | J | J | A | S | O | N | D | TOTAL |
| 1978 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 0 | 2 | 1 | 1 | 1 | 13 |
| 1979 | 1 | 1 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 12 |
| 1980 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 11 |
| 1981 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 9 |
| 1982 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 6 |
| 1983 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 3 |
| 1984 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 4 |
| 1985 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 4 |
| 1986 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 6 |
| | | | | | | | | | | | | | 68 |

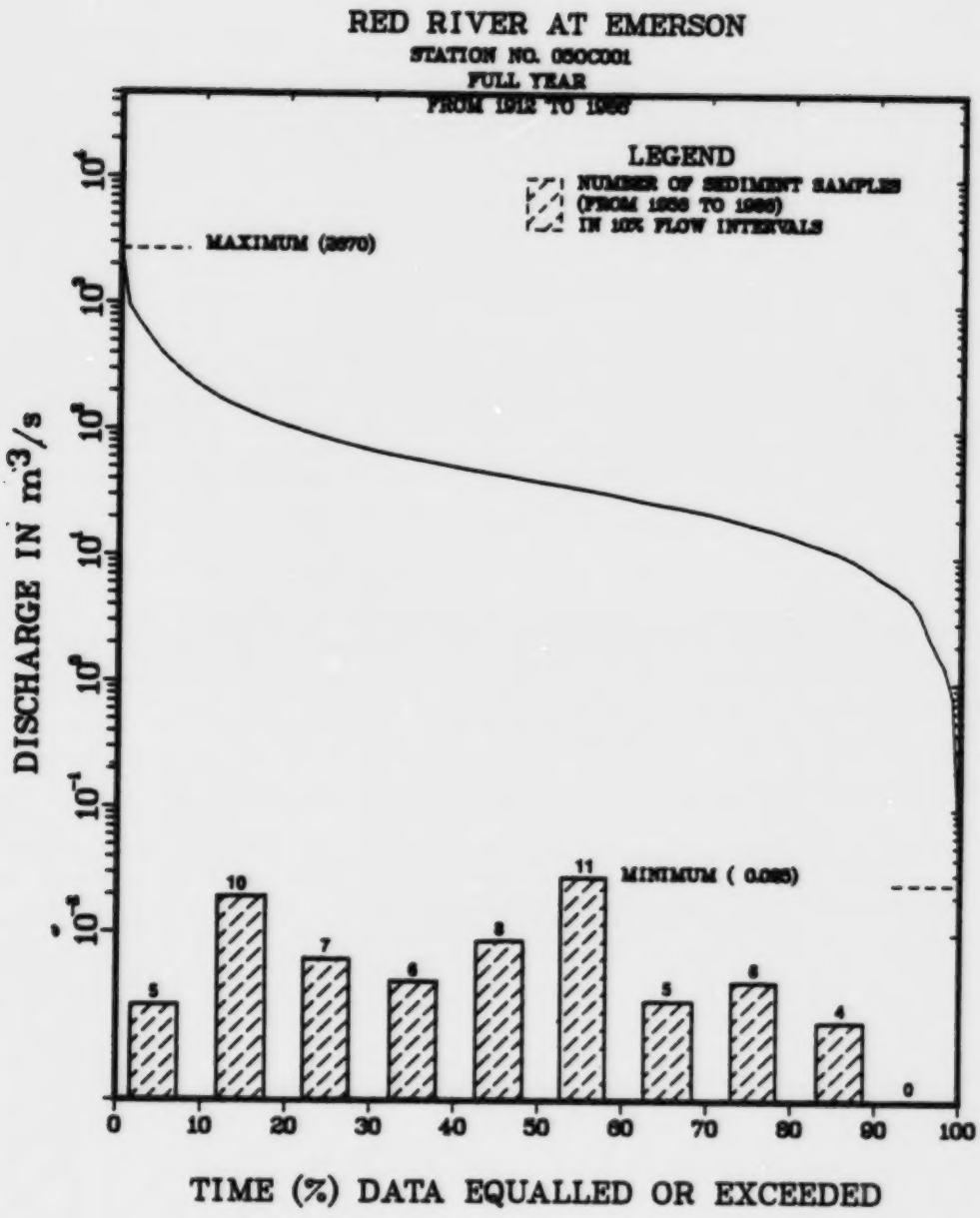



**Figure 6. Flow Duration Diagram for Daily Mean Discharges from 1912 to 1986. Number of USGS Suspended Sediment Samples Collected from 1978 to 1986 in 10% Flow Intervals**

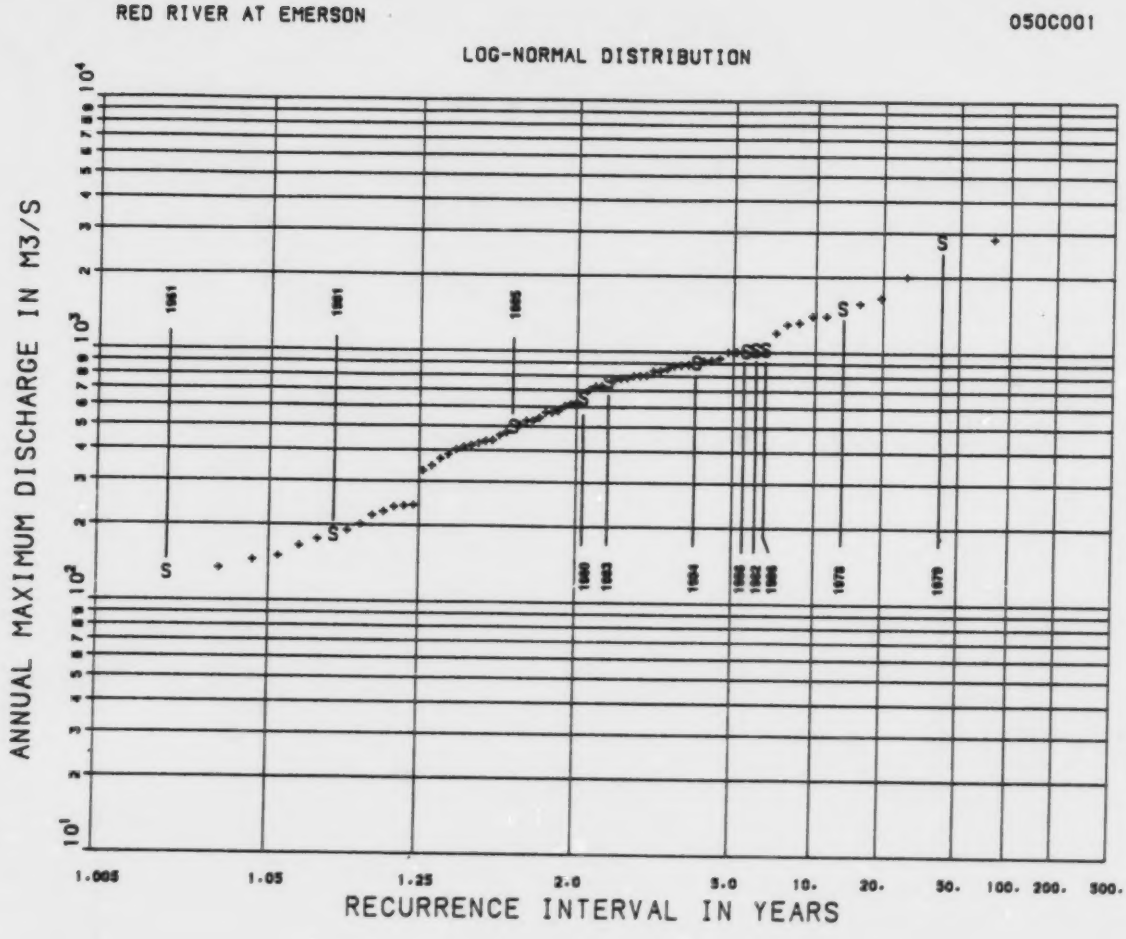



**Figure 7. Frequency Plot of Annual Maximum Daily Flows**

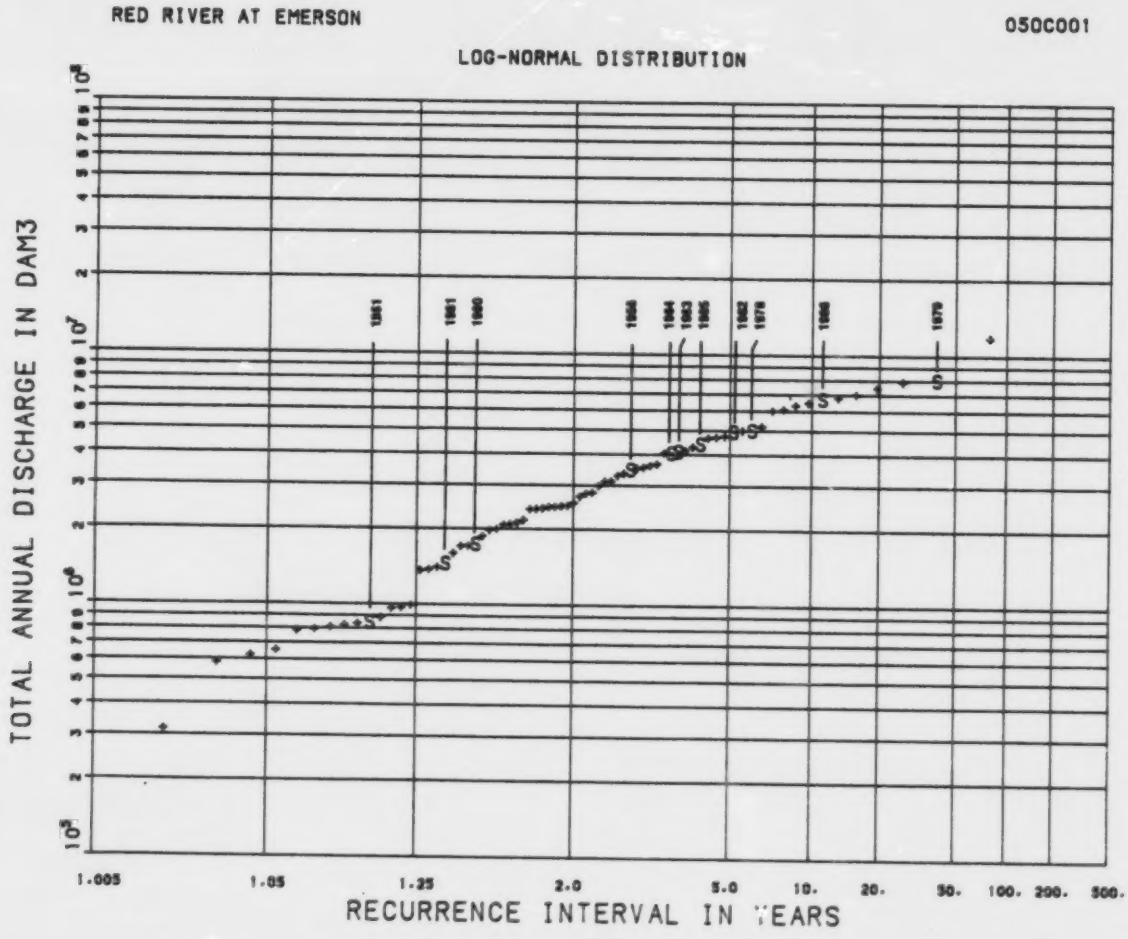



**Figure 8. Frequency Plot of Total Annual Flow**

runoff and during summer high flows. A typical annual sequence of flows is shown in Figure 9. By contrast the USGS sampling strategy does not lead to good within year flow coverage. In fact, as shown in Table 4, the USGS program has not yet collected any samples during annual peak flows.

Therefore, while the WSC program provides good documentation of within-year flow variation, and has collected data across a good annual peak flow range, it is not as representative of the annual series of total discharge.

While the USGS data program is not designed to document in a comprehensive manner the sediment regime it is noteworthy to mention that any statistical analysis of their data for trend assessment would be inappropriate until a better flow range is sampled.

### 3.4 Compatibility of Data

The WSC sediment concentration data base contains over 800 samples, while the USGS data base contains 67 samples. Of these, only 16 samples were obtained on common days. Table 5 lists the days that these common samples were taken, the time, the concentration, and the percent difference between each method. Both programs sampled from the same bridge.

WSC methodology approximates the average concentration of the cross section. USGS methodology should yield values that are closer to the

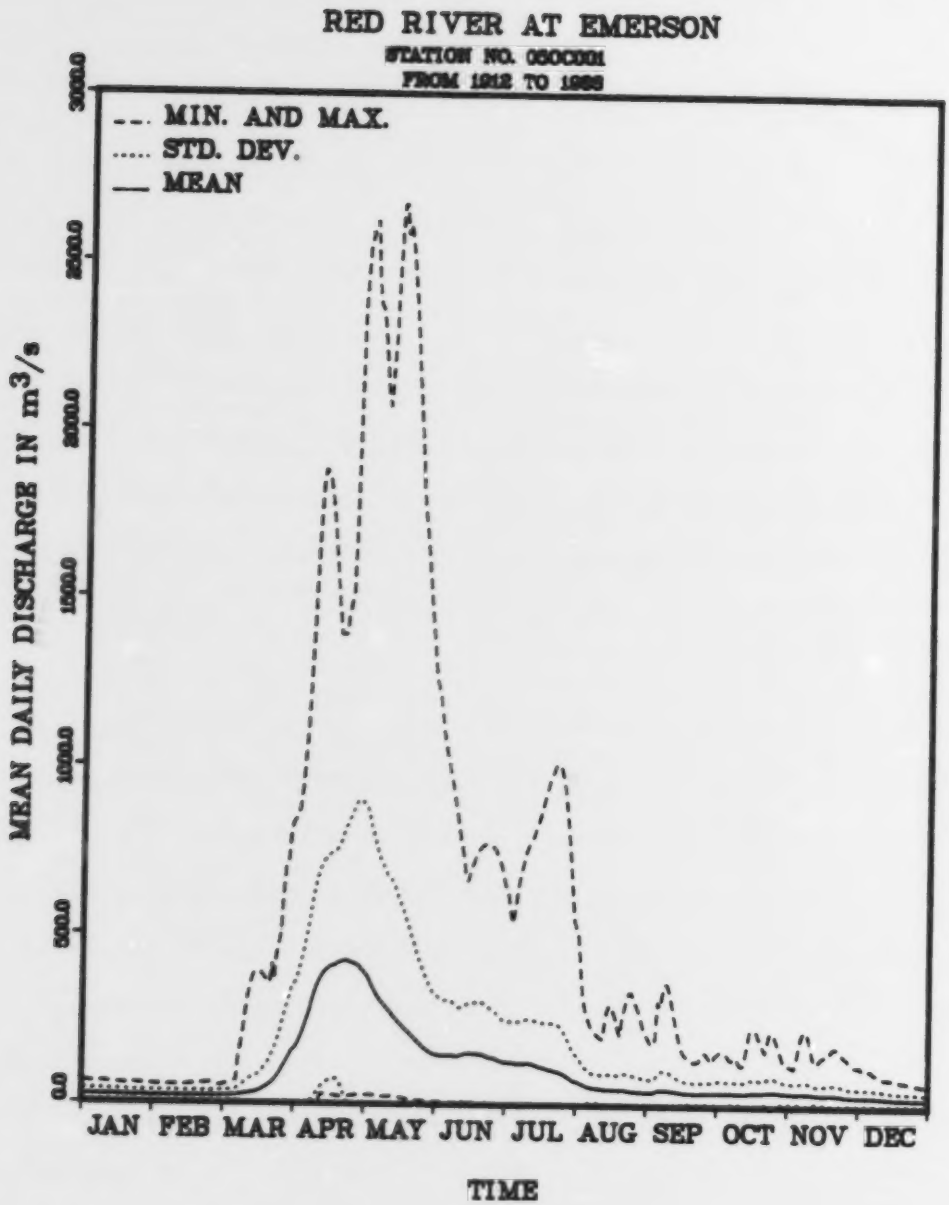



Figure 9. Flow Histogram

Table 4. Date of Maximum Daily Discharge for Each Year for the Period 1978-1986 and the Nearest Days the USGS Sampled.

| Year | Date of maximum daily discharges for the year | USGS nearest date sampled Before | After |
|---|---|---|---|
| 1978 | April 18 | March 22 | April 27 |
| 1979 | May 1 | March 20 | May 10 |
| 1980 | April 10 | March 25 | April 30 |
| 1981 | July 4 | June 10 | July 7 |
| 1982 | April 18 | Feb. 24 | April 27 |
| 1983 | April 10 | March 9 | June 29 |
| 1984 | April 8 | Jan. 10 | April 10 |
| 1985 | March 29 | March 13 | May 2 |
| 1986 | April 7 | March 4 | April 29 |

true average concentration as each measurement covers the complete cross section. Therefore, the comparison between the two data sets is based on how well the WSC data matched the USGS data.

An examination of Table 5 shows that the largest difference is 100%, which occurred on July 16, 1986. WSC records indicate that the preceding and following days each had a daily mean concentration of 309 mg/L and 300 mg/L respectively. USGS records indicate that two EWI measurements where taken each having a concentration of 144 mg/L and 150 mg/L. Furthermore, on July 16, 1986, both the USGS and WSC sampled within two and a half hours of each other and WSC performed an EDI measurement. These facts make it impossible to determine the correct value, therefore, values for this day are not included in the analysis.

Examining the two next largest differences, reveals inconclusive results. Both sets of data occurred in 1982, on April 27 and August 24, each having a 63% and 73% difference, respectively. WSC records indicate that their concentrations obtained on these days were consistent with those of the preceding and following days. However, on these days, USGS and WSC sampled up to 7 hours apart. Analysis of the data where sampling was done twice in one day, revealed that variation was usually less than 15%, but could be as much as 66%. Therefore, these values are included in the analysis.

In Figure 10, the data are plotted against each other. A best fit line was drawn using the least squares method. The plot shows a linear relationship with a slope of almost one. Further analysis,

Table 5. Common Days that WSC and USGS Sampled

| Year | Date | USGS Time | USGS Conc. | WSC Time | WSC Conc. | MAX. % DIFF. of Conc. | Discharge $m^3/s$ |
|---|---|---|---|---|---|---|---|
| 1978 | Apr 27 | 1300 | 52 | 1430 | 65 | 25.0 | 1130 |
| 1979 | Jun 01 | 1225 | 212 | 1330 | 227 | 7.1 | 404 |
| | Jun 28 | 1100 | 220 | | 239 | 8.6 | 180 |
| | Aug 30 | 1120 | 122 | 1200 | 132 | 8.2 | 76 |
| 1980 | Apr 30 | 1025 | 118 | 0800 | 126 | 6.8 | 94.3 |
| | May 12 | 1200 | 115 | 0800 | 124 | 7.8 | 71.1 |
| 1981 | Apr 15 | 1015 | 140 | 0700 | 157 | 12.1 | 46.8 |
| | Jul 07 | 1030 | 510 | 0700 | 474 | 7.6 | 108 |
| | Aug 13 | 1240 | 196 | 1140 | 204 | 4.1 | 54.2 |
| 1982 | Apr 27 | 1335 | 213 | 0800 | 131 | 62.6 | 663 |
| | Aug 24 | 1310 | 166 | 2015 | 96 | 72.9 | 53.4 |
| 1985 | Aug 13 | 1645 | 266 | 1900 | 259 | 2.7 | 149 |
| | Nov 05 | 1300 | 41 | 0800 | 42 | 2.4 | 107 |
| 1986 | Apr 29 | 1340 | 150 | 0800 | 149 | 0.7 | 688 |
| | Jul 16 | 1230 | 147 | 1000 | 295 | 100.7 | 138 |
| | Aug 22 | 1100 | 163 | 1200 | 123 | 32.5 | 70.8 |
| | | Mean | 177 | | 178 | 0 | |

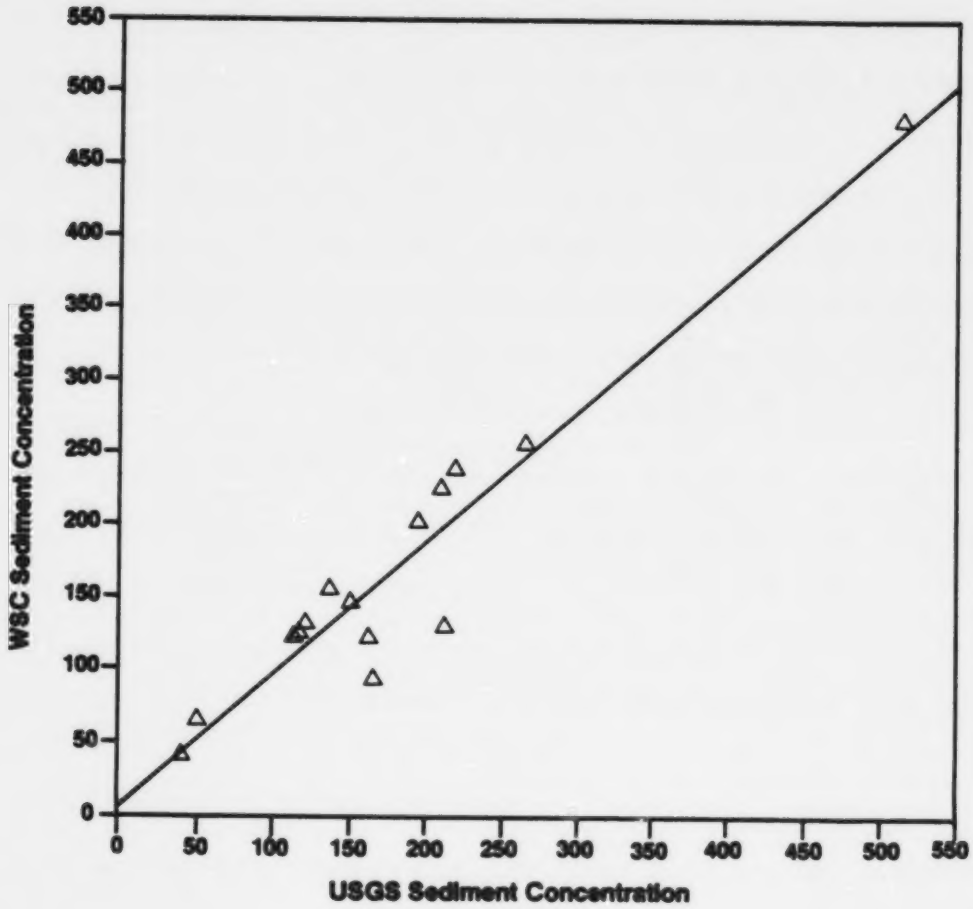



**Figure 10. Comparison of WSC and USGS Data**

revealed an $R^2$ value of 0.86. Hence, 86% of the variance about the WSC mean is explained by the regression line. Analysis also revealed that the slope of the regression line is not significantly different from a slope of one. Similarly, the y-intercept was found to be not significantly different from a y-intercept of zero. The USGS data, in general, tends to produce higher concentrations.

Possible explanations for the variation about the 1:1 line include human error, errors resulting from the methodologies and sampling at different times. However, a good relationship between the two data sets exists, indicating they can be used together in any analysis.

# 4. Summary and Interpretation of Data

## 4.1 Lateral Variation in Concentration

The Red River at Emerson has fairly homogeneous lateral suspended sediment concentrations. Table 6 lists each EDI measurement that has been taken since 1978. From each EDI measurement, an average suspended sediment concentration for the entire cross section is determined. The individual concentration for each panel is compared to the average concentration for the cross section and a percent difference is calculated. These differences are also listed in Table 6 as well as the mean and maximum percent difference for all panels. Figure 11 plots the mean and maximum percent difference for each panel. The figure shows that the mean percent difference for all panels is less than 4%. The maximum variation in the cross section is 26%. It should be noted that the center panel, where the single vertical sample is taken, has the smallest value for mean percent difference of all the panels.

WSC performed three full point integrated measurements in 1979, 1980 and 1982. Each measurement consists of seven samples (at different depths) for each of the five panels in the cross section. The concentration of each sample is compared to the average concentration. The resulting percent differences and the mean and maximum of these differences are listed in Table 7. Figure 12 clearly shows that the concentration in the cross section is homogeneous. The two points that show a 59% and 43% difference (1982 and 1980 measurements, respectively) appear to be anomalies.

Table 6. Summary of EDI Measurements Containing Date, Concentrations for Each Panel and the Average Cross Section Concentration are Listed. The Percent Difference Between the Panel Concentration and the Average Cross Section Concentration are Also Listed.

| DATE | | Conc. at each 20% panel in the X-section | | | | | Avg. Conc. | Percent difference from the average concentration | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 4th | 5th | | 1st | 2nd | 3rd | 4th | 5th |
| 1986 | Mar 13+ | 12 | 10 | 10 | 11 | 10 | 11 | 13 | 6 | 6 | 4 | 6 |
| | Mar 31 | 355 | 371 | 364 | 352 | 364 | 361 | 2 | 3 | 1 | 3 | 1 |
| | Apr 02 | 324 | 344 | 322 | 333 | 337 | 332 | 2 | 4 | 3 | 0 | 2 |
| | Apr 08 | 146 | 144 | 179 | 144 | 151 | 153 | 4 | 6 | 17 | 6 | 1 |
| | Apr 21 | 368 | 365 | 368 | 347 | 379 | 365 | 1 | 0 | 1 | 5 | 4 |
| | May 06 | 98 | 102 | 108 | 95 | 100 | 101 | 3 | 1 | 7 | 6 | 1 |
| | May 20 | 113 | 118 | 117 | 114 | 114 | 115 | 2 | 2 | 2 | 1 | 1 |
| | Jun 17 | 242 | 244 | 239 | 238 | 237 | 240 | 1 | 2 | 0 | 1 | 1 |
| | Jul 16 | 302 | 289 | 272 | 326 | 288 | 295 | 2 | 2 | 8 | 10 | 3 |
| | Aug 19 | 129 | 136 | 137 | 106 | 133 | 128 | 1 | 6 | 7 | 17 | 4 |
| | Sep 23 | 97 | 97 | 98 | 93 | 89 | 95 | 2 | 2 | 3 | 2 | 6 |
| | Oct 24 | 68 | 70 | 69 | 69 | 67 | 69 | 1 | 2 | 1 | 1 | 2 |
| 1985 | Mar 22 | 208 | 191 | 177 | 184 | 226 | 195 | 7 | 2 | 9 | 6 | 16 |
| | Apr 03 | 245 | 234 | 241 | 238 | 239 | 240 | 2 | 3 | 0 | 1 | 0 |
| | Apr 08 | 456 | 447 | 448 | 455 | 450 | 452 | 1 | 1 | 1 | 1 | 0 |
| | Apr 16 | 596 | 565 | 560 | 561 | 572 | 573 | 4 | 1 | 2 | 2 | 0 |
| | May 06 | 258 | 266 | 256 | 253 | 255 | 261 | 1 | 2 | 2 | 3 | 2 |
| | May 17 | 1929 | 1890 | 1879 | 1871 | 1865 | 1891 | 2 | 0 | 1 | 1 | 1 |
| | May 22 | 362 | 390 | 359 | 368 | 407 | 377 | 4 | 3 | 5 | 2 | 8 |
| | May 28 | 176 | 173 | 171 | 170 | 170 | 172 | 2 | 1 | 1 | 1 | 1 |
| | Jun 26 | 348 | 363 | 377 | 362 | 349 | 359 | 3 | 1 | 5 | 1 | 3 |
| | Jul 05 | 184 | 184 | 180 | 158 | 180 | 177 | 4 | 4 | 2 | 11 | 2 |
| | Aug 07 | 302 | 319 | 311 | 309 | 337 | 313 | 4 | 2 | 1 | 1 | 8 |
| | Aug 27 | 171 | 173 | 166 | 169 | 170 | 170 | 1 | 2 | 2 | 1 | 0 |
| | Sep 24 | 201 | 208 | 201 | 201 | 198 | 202 | 0 | 3 | 0 | 0 | 2 |
| | Oct 23 | 77 | 77 | 75 | 73 | 73 | 75 | 3 | 3 | 0 | 3 | 3 |
| | Dec 05+ | 9 | 13 | 11 | 11 | 9 | 11 | 15 | 23 | 4 | 4 | 15 |
| 1984 | Mar 07+ | 17 | 13 | 10 | 13 | 11 | 13 | 33 | 2 | 22 | 2 | 14 |
| | Apr 07 | 328 | 268 | 362 | 367 | 368 | 317 | 3 | 15 | 14 | 16 | 16 |
| | Apr 09 | 306 | 294 | 272 | 275 | 289 | 290 | 6 | 1 | 6 | 5 | 0 |
| | Apr 12 | 157 | 166 | 181 | 173 | 178 | 169 | 7 | 2 | 7 | 2 | 5 |
| | Apr 19 | 108 | 105 | 106 | 105 | 106 | 106 | 2 | 1 | 0 | 1 | 0 |
| | Apr 30 | 213 | 256 | 217 | 212 | 214 | 222 | 4 | 15 | 2 | 5 | 4 |
| | Jun 05 | 96 | 99 | 102 | 97 | 92 | 98 | 2 | 1 | 4 | 1 | 6 |
| | Jun 18 | 142 | 150 | 148 | 147 | 146 | 146 | 3 | 3 | 1 | 1 | 0 |
| | Jun 20 | 80 | 79 | 79 | 77 | 76 | 78 | 3 | 1 | 1 | 1 | 3 |
| | Jun 25 | 114 | 112 | 110 | 121 | 95 | 110 | 4 | 2 | 0 | 10 | 14 |

Table 6. Con't

| DATE | | Conc. at each 20% panel in the X-section | | | | | Avg. Conc. | Percent difference from the average concentration | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 4th | 5th | | 1st | 2nd | 3rd | 4th | 5th |
| | Jul 04 | 352 | 358 | 347 | 348 | 345 | 350 | 1 | 2 | 1 | 1 | 1 |
| | Aug 29 | 116 | 117 | 122 | 111 | 121 | 117 | 1 | 0 | 4 | 5 | 3 |
| | Nov 06 | 79 | 80 | 74 | 74 | 78 | 77 | 3 | 4 | 4 | 4 | 1 |
| | Dec 10+ | 18 | 17 | 18 | 17 | 20 | 18 | 0 | 6 | 0 | 6 | 11 |
| 1983 | Jan 05+ | 30 | 24 | 23 | 10 | 14 | 20 | 49 | 19 | 14 | 50 | 31 |
| | Apr 11 | 280 | 289 | 277 | 289 | 267 | 281 | 0 | 3 | 1 | 3 | 5 |
| | Apr 13 | 233 | 232 | 228 | 232 | 222 | 230 | 1 | 1 | 1 | 1 | 3 |
| | Apr 19 | 245 | 238 | 249 | 244 | 243 | 244 | 0 | 2 | 2 | 0 | 0 |
| | May 19 | 167 | 167 | 167 | 165 | 159 | 165 | 1 | 1 | 1 | 0 | 4 |
| | Jun 20 | 582 | 594 | 595 | 588 | 608 | 592 | 2 | 0 | 1 | 1 | 3 |
| | Jul 11 | 378 | 388 | 372 | 378 | 379 | 379 | 0 | 2 | 2 | 0 | 0 |
| | Aug 10 | 177 | 181 | 178 | 175 | 174 | 177 | 0 | 2 | 1 | 1 | 2 |
| | Sep 27 | 121 | 120 | 119 | 119 | 120 | 120 | 1 | 0 | 1 | 1 | 0 |
| | Nov 13 | 48 | 47 | 48 | 48 | 48 | 54 | 0 | 2 | 0 | 0 | 0 |
| | Dec 12++ | 13 | 102 | 187 | 184 | 89 | 115 | 89 | 11 | 63 | 60 | 23 |
| 1982 | Mar 03+ | 13 | 9 | 10 | 11 | 11 | 11 | 20 | 17 | 7 | 2 | 2 |
| | Apr 13 | 251 | 272 | 255 | 247 | 240 | 253 | 1 | 8 | 1 | 2 | 5 |
| | Apr 17 | 408 | 401 | 396 | 392 | 380 | 404 | 3 | 1 | 0 | 1 | 4 |
| | Apr 22 | 193 | 177 | 211 | 185 | 212 | 197 | 2 | 10 | 7 | 6 | 8 |
| | Apr 29 | 121 | 122 | 123 | 122 | 124 | 123 | 2 | 1 | 0 | 1 | 1 |
| | May 06 | 357 | 372 | 368 | 353 | 361 | 362 | 1 | 3 | 2 | 2 | 0 |
| | May 18 | 219 | 220 | 226 | 227 | 215 | 222 | 1 | 1 | 2 | 2 | 3 |
| | Jun 09 | 1614 | 1651 | 1641 | 1600 | 1565 | 1621 | 0 | 2 | 1 | 1 | 3 |
| | Jun 22 | 282 | 284 | 279 | 283 | 276 | 281 | 0 | 1 | 1 | 1 | 3 |
| | Aug 03 | 333 | 345 | 336 | 334 | 277 | 328 | 2 | 5 | 2 | 2 | 16 |
| | Sep 14 | 109 | 101 | 102 | 92 | 99 | 99 | 10 | 2 | 3 | 7 | 0 |
| | Oct 13 | 328 | 317 | 305 | 309 | 310 | 315 | 4 | 1 | 3 | 2 | 2 |
| | Nov 10 | 63 | 63 | 64 | 63 | 63 | 63 | 0 | 0 | 2 | 0 | 0 |
| 1981 | Apr 02 | 234 | 238 | 220 | 236 | 225 | 230 | 2 | 3 | 4 | 3 | 2 |
| | May 06 | 102 | 103 | 107 | 110 | 112 | 108 | 6 | 5 | 1 | 2 | 4 |
| | Jun 02 | 707 | 670 | 669 | 658 | 612 | 666 | 6 | 1 | 0 | 1 | 8 |
| | Jul 15 | 296 | 301 | 307 | 305 | 289 | 301 | 2 | 0 | 2 | 1 | 4 |
| | Aug 13 | 195 | 187 | 201 | 201 | 190 | 195 | 0 | 4 | 3 | 3 | 3 |
| | Sep 30 | 75 | 75 | 79 | 74 | 73 | 75 | 0 | 0 | 5 | 1 | 3 |
| | Dec 22 | 132 | 130 | 128 | 87 | 114 | 119 | 11 | 9 | 8 | 27 | 4 |

Table 6. Con't

| DATE | | Conc. at each 20% panel in the X-section 1st | 2nd | 3rd | 4th | 5th | Avg. Conc. | Percent difference from the average concentration 1st | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | Jan 15 | 65 | 58 | 65 | 48 | 48 | 55 | 14 | 2 | 14 | 15 | 15 |
| | Mar 18+ | 14 | 12 | 9 | 8 | 11 | 11 | 30 | 11 | 17 | 26 | 2 |
| | Apr 09 | 581 | 596 | 600 | 601 | 611 | 596 | 3 | 0 | 1 | 1 | 3 |
| | Apr 15 | 186 | 175 | 182 | 179 | 178 | 180 | 3 | 3 | 1 | 1 | 1 |
| | May 09+ | 96 | 93 | 139 | 99 | 95 | 104 | 8 | 11 | 33 | 5 | 9 |
| | Jun 03 | 108 | 116 | 122 | 122 | 129 | 121 | 11 | 4 | 1 | 1 | 7 |
| | Jun 27 | 243 | 253 | 261 | 264 | 268 | 259 | 6 | 2 | 1 | 2 | 3 |
| | Aug 08 | 101 | 105 | 110 | 112 | 116 | 109 | 7 | 4 | 1 | 3 | 6 |
| | Sep 09 | 260 | 273 | 280 | 264 | 270 | 270 | 4 | 1 | 4 | 2 | 0 |
| | Oct 06 | 65 | 64 | 65 | 67 | 69 | 66 | 2 | 3 | 2 | 2 | 5 |
| | Dec 22+ | 23 | 9 | 12 | 10 | 10 | 13 | 80 | 30 | 6 | 22 | 22 |
| 1979 | Mar 22+ | 13 | 12 | 9 | 12 | 15 | 12 | 7 | 2 | 26 | 2 | 23 |
| | Apr 24 | 363 | 361 | 378 | 329 | 380 | 363 | 0 | 1 | 4 | 9 | 5 |
| | Apr 27 | 199 | 245 | 239 | 230 | 258 | 232 | 14 | 6 | 3 | 1 | 11 |
| | Apr 30 | 168 | 174 | 182 | 180 | 190 | 178 | 6 | 2 | 2 | 1 | 7 |
| | May 02 | 151 | 157 | 182 | 185 | 184 | 169 | 11 | 7 | 8 | 9 | 9 |
| | May 04 | 145 | 169 | 164 | 179 | 198 | 170 | 15 | 1 | 4 | 5 | 16 |
| | May 07 | 117 | 141 | 157 | 150 | 163 | 146 | 20 | 3 | 8 | 3 | 12 |
| | May 11 | 124 | 142 | 153 | 156 | 163 | 146 | 15 | 3 | 5 | 7 | 12 |
| | May 15 | 140 | 145 | 149 | 149 | 149 | 146 | 4 | 1 | 2 | 2 | 2 |
| | May 18 | 148 | 155 | 154 | 149 | 162 | 153 | 3 | 1 | 1 | 3 | 6 |
| | Jun 01 | 227 | 230 | 216 | 215 | 232 | 224 | 1 | 3 | 4 | 4 | 4 |
| | Jun 27 | 253 | 246 | 243 | 244 | 234 | 245 | 3 | 0 | 1 | 0 | 4 |
| | Aug 14 | 262 | 244 | 251 | 245 | 286 | 258 | 2 | 5 | 3 | 5 | 11 |
| | Oct 04 | 101 | 98 | 104 | 106 | 103 | 103 | 2 | 5 | 1 | 3 | 0 |
| | Oct 29+ | 34 | 31 | 35 | 35 | 34 | 34 | 1 | 8 | 4 | 4 | 1 |
| 1978 | Mar 31 | 318 | 318 | 307 | 310 | 299 | 312 | 2 | 2 | 2 | 1 | 4 |
| | Apr 05 | 365 | 377 | 379 | 366 | 351 | 368 | 1 | 2 | 3 | 1 | 1 |
| | Apr 12 | 545 | 534 | 559 | 551 | 543 | 546 | 0 | 2 | 2 | 1 | 1 |
| | Apr 19 | 224 | 236 | 217 | 241 | 231 | 230 | 3 | 3 | 6 | 5 | 0 |
| | Apr 27 | 65 | 66 | 64 | 63 | 61 | 64 | 2 | 3 | 0 | 2 | 5 |
| | May 09 | 210 | 210 | 206 | 199 | 208 | 207 | 1 | 1 | 0 | 4 | 0 |
| | Jun 07 | 236 | 244 | 235 | 227 | 217 | 232 | 2 | 5 | 1 | 2 | 5 |
| | Jun 30 | 318 | 316 | 320 | 324 | 301 | 317 | 0 | 0 | 1 | 2 | 5 |
| | Jul 31 | 259 | 274 | 269 | 297 | 281 | 272 | 5 | 1 | 1 | 9 | 3 |
| | Aug 30 | 101 | 102 | 104 | 103 | 106 | 102 | 2 | 1 | 1 | 0 | 3 |

Table 6. Con't

| DATE | Conc. at each 20% panel in the X-section | | | | | Avg. Conc. | Percent difference from the average concentration | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | | 1st | 2nd | 3rd | 4th | 5th |
| Sep 29 | 83 | 88 | 89 | 86 | 84 | 86 | 3 | 2 | 3 | 0 | 2 |
| Nov 09+ | 39 | 38 | 37 | 37 | 38 | 38 | 3 | 1 | 2 | 2 | 1 |
| Nov 30+ | 20 | 17 | 21 | 15 | 19 | 18 | 9 | 8 | 14 | 18 | 3 |
| | | | | | | mean | 3.4 | 2.8 | 2.7 | 3.1 | 3.8 |
| | | | | | | max. | 20 | 21 | 17 | 26 | 16 |

\+ Concentrations lower than 50 mg/L not used in the calculation of mean due to low accuracy.

++ Values appear to be anomalies.

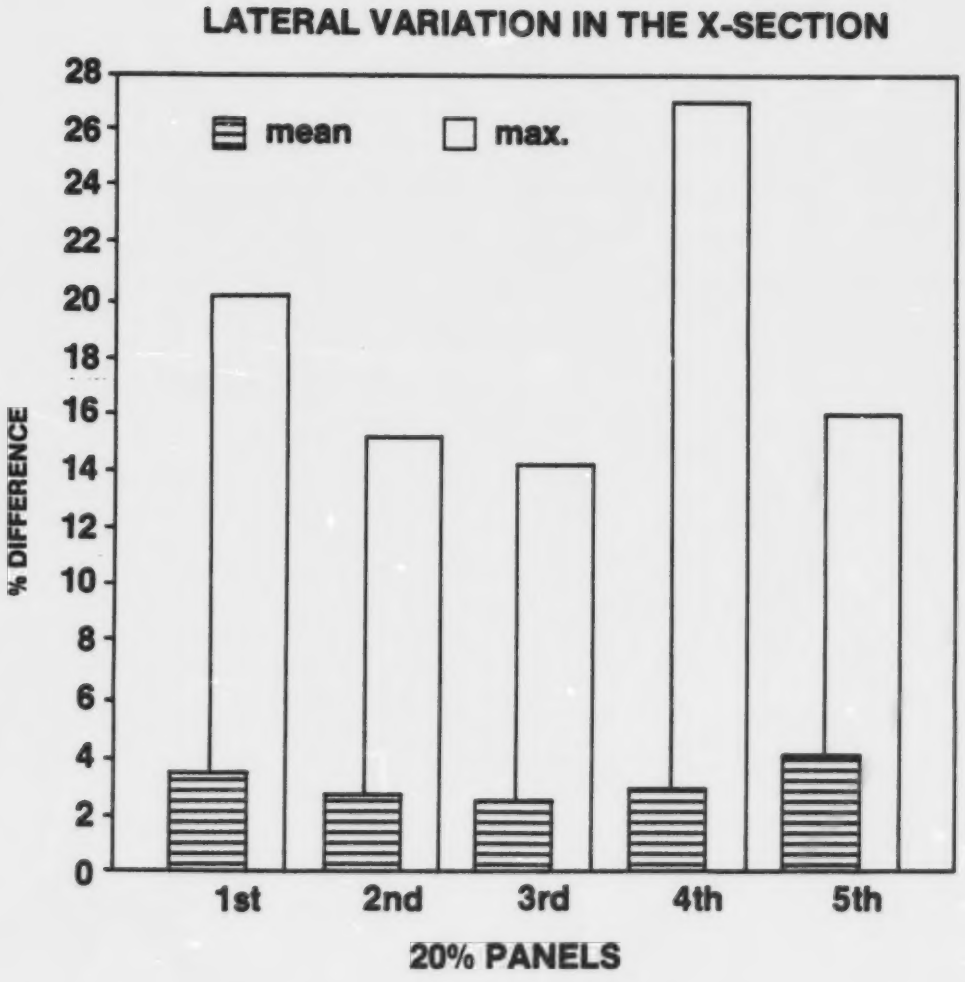



Figure 11. Bargraph Showing the Mean and Maximum Percent Difference from the Average Concentration for each 20% Panel

Table 7. Point Integrated Measurements and the Percent Difference from the Mean Concentration.

| Date | Point Conc. at each 20% panel in the X-section | | | | | Average Conc. | Daily mean Conc. | Percent difference from the mean conc. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | | | 1st | 2nd | 3rd | 4th | 5th |
| 5/2/79 | 141 | 159 | 183 | 203 | 209 | 176 | 170 | 20 | 10 | 4 | 15 | 19 |
| | 153 | 157 | 185 | 187 | 199 | | | 13 | 11 | 5 | 6 | 13 |
| | 156 | 166 | 184 | 181 | 201 | | | 11 | 6 | 5 | 3 | 14 |
| | 152 | 153 | 183 | 190 | 207 | | | 14 | 13 | 4 | 8 | 18 |
| | 149 | 157 | 174 | 197 | 203 | | | 15 | 11 | 1 | 12 | 15 |
| | 151 | 163 | 171 | 181 | 184 | | | 14 | 7 | 3 | 3 | 5 |
| | 165 | 163 | 178 | 179 | 184 | | | 6 | 7 | 1 | 2 | 5 |
| 4/15/80 | 177 | 160 | 175 | 170 | 171 | 177 | 182 | 0 | 10 | 1 | 4 | 3 |
| | 167 | 159 | 170 | 174 | 167 | | | 6 | 10 | 4 | 2 | 6 |
| | 167 | 161 | 172 | 176 | 171 | | | 6 | 9 | 3 | 1 | 3 |
| | 170 | 163 | 172 | 173 | 207 | | | 4 | 8 | 3 | 2 | 17 |
| | 171 | 160 | 172 | 176 | 175 | | | 3 | 10 | 3 | 1 | 1 |
| | 281 | 190 | 177 | 176 | 177 | | | 59+ | 7 | 0 | 1 | 0 |
| | 175 | 180 | 182 | 178 | 209 | | | 1 | 2 | 3 | 1 | 18 |
| 4/17/82 | 388 | 414 | 371 | 389 | 394 | 409 | 404 | 5 | 1 | 9 | 5 | 4 |
| | 409 | 405 | 397 | 388 | 402 | | | 0 | 1 | 3 | 5 | 2 |
| | 425 | 416 | 397 | 402 | 377 | | | 4 | 2 | 3 | 2 | 8 |
| | 404 | 435 | 413 | 402 | 378 | | | 1 | 6 | 1 | 2 | 8 |
| | 584 | 419 | 400 | 395 | 419 | | | 43+ | 2 | 2 | 3 | 2 |
| | 382 | 415 | 408 | 414 | 409 | | | 7 | 1 | 0 | 1 | 0 |
| | 385 | 410 | 428 | 408 | 418 | | | 6 | 0 | 5 | 0 | 2 |
| | | | | | | | mean | 7 | 6 | 3 | 4 | 8 |
| | | | | | | | max. | 59 | 13 | 9 | 15 | 19 |

Note: + Anomalies

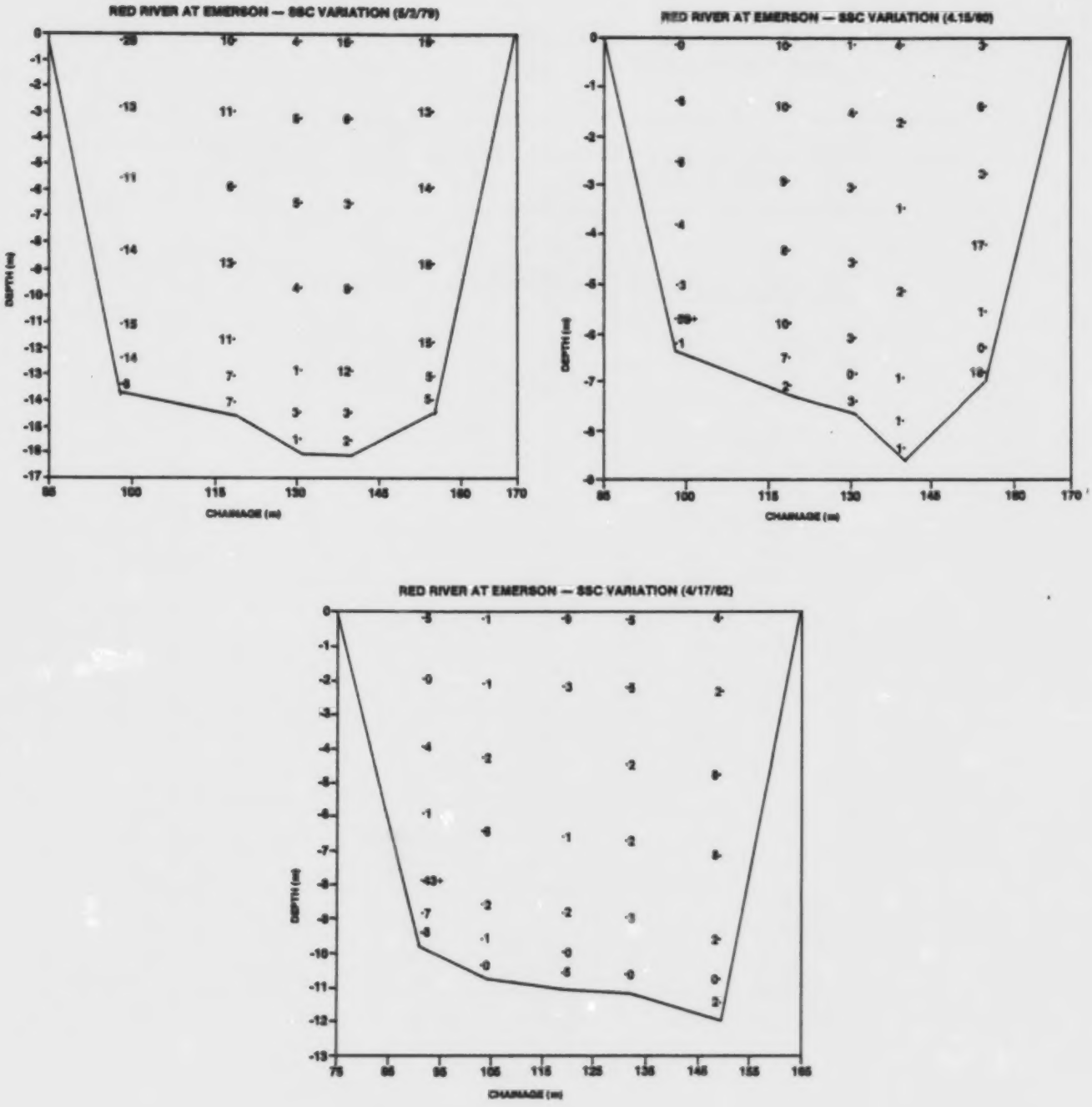

RED RIVER AT EMERSON — SSC VARIATION (5/2/79)
RED RIVER AT EMERSON — SSC VARIATION (4.15/80)
RED RIVER AT EMERSON — SSC VARIATION (4/17/82)
DEPTH (m)
CHAINAGE (m)

**Figure 12. Percent Difference Between Point Concentration and Mean Concentration for Each Point Integrated Measurement**

These data (EDI and point integrated measurements) support WSC's decision to use the single vertical method to determine the average concentration in the cross section. They also show that the most suitable panel was chosen since the mean and maximum percent difference for the center panel are about 2.7% and 17% for EDI measurements and 3% and 9% for point integrated measurements.

Water Survey of Canada uses a k-factor, which is a correction that is applied to the single vertical so the results are comparable to those obtained from a full measurenent. The factor takes the form of $C_a/C_v$, where $C_v$ is the concentration in the representative vertical and $C_a$ is the average concentration obtained from the EDI measurement. At Emerson, the k-factor varied from a low of 0.83 (1983) to a high of 1.32 (1979). For most of the period the correction fell within $\pm$ 10%.

## 4.2 Particle Size Characteristics

### 4.2.1 Particle Size Characteristics: Suspended Sediment

The particle size characteristics of the suspended sediment are illustrated in Figure 13. The figure shows the percent finer versus the particle size. The figure illustrates that the suspended sediment of the Red River at Emerson contains no particles larger than 1 mm. Figure 14 shows that silt and clay particles make up between 90 and 100 percent of

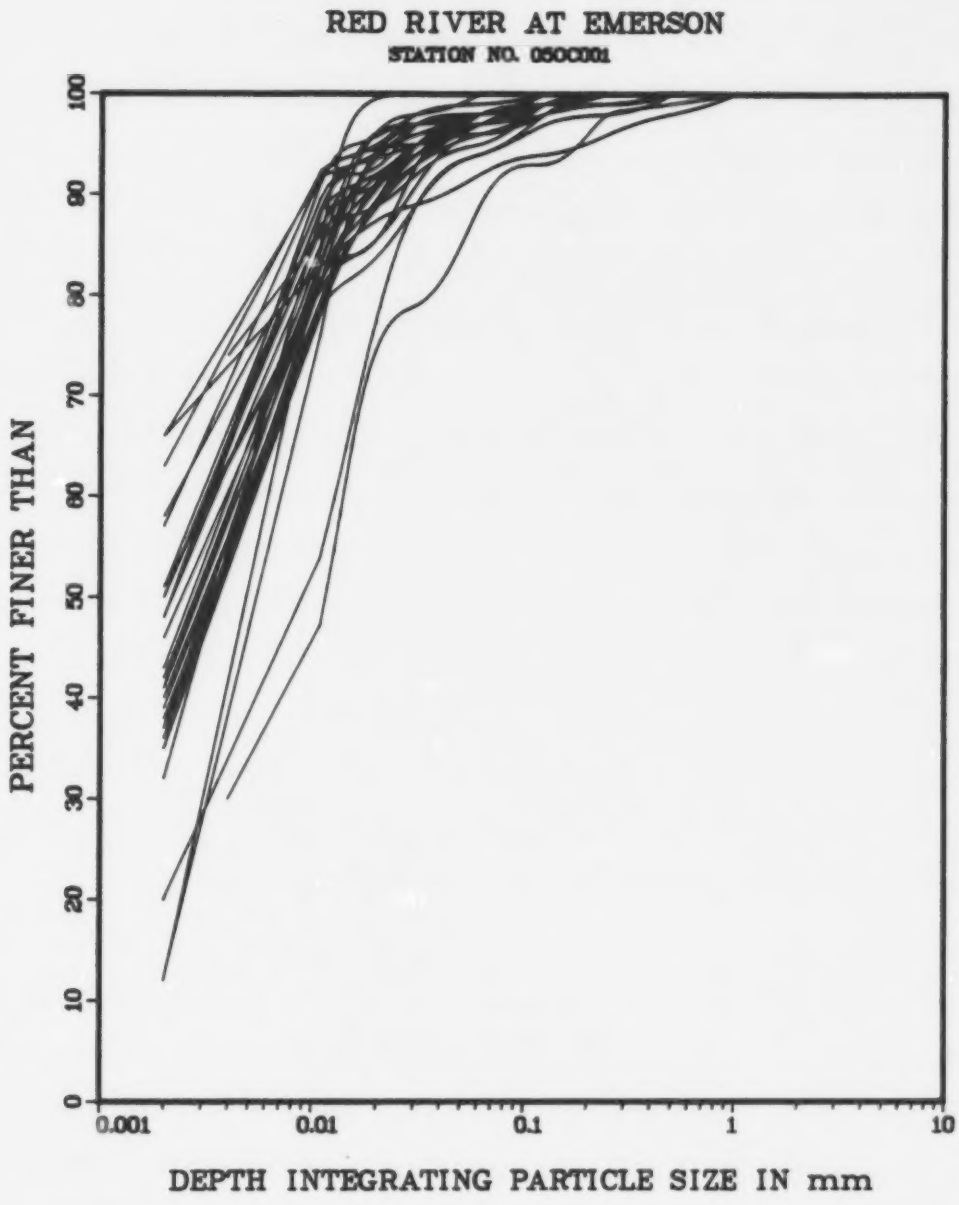



**Figure 13. Composite Plot of 33 Suspended Sediment Particle Distribution Samples Collected During the Period 1956-1986**

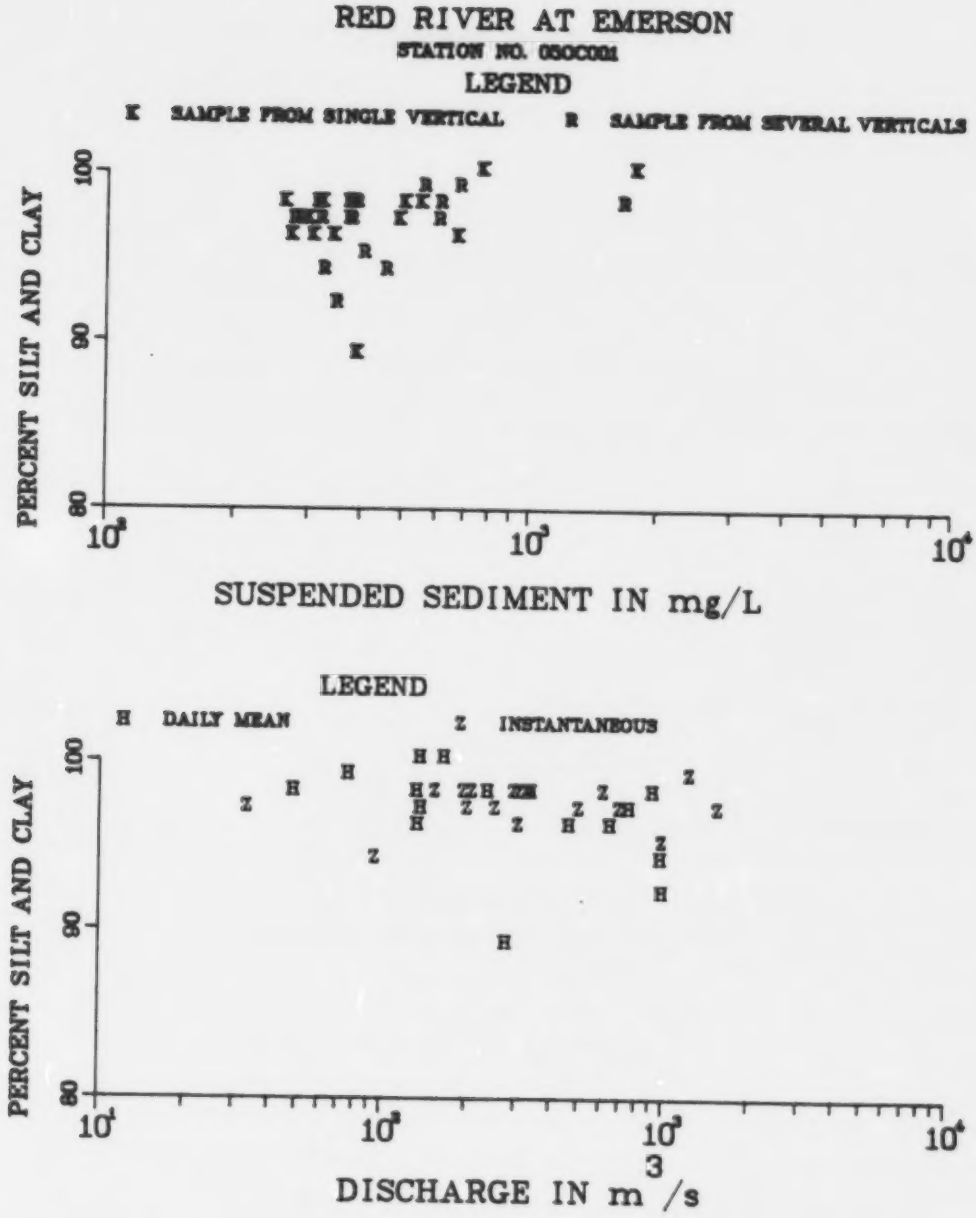



Figure 14. Variation of Silt and Clay Fraction with Discharge and Concentration

the suspended sediment regardless of the concentration and discharge in the river at the time of sampling. The upper and lower limit of both the concentration and discharge in these figures are 281 mg/L to 1 730 mg/L and 32 $m^3/s$ to 1 500 $m^3/s$, respectively. Figure 14 illustrates that both ranges are well covered.

### 4.2.2 Particle Size Characteristics: Bed Material

Particle size gradation curves of bed material measurements are shown in Figure 15. Four out of the five measurements are composed of five sampling points. The fifth measurement is composed of only two sampling points. The plot shows that the predominant material is silt and clay, comprising from 57% to 81% of the total with the average being 72%. Sand and gravel each make up between 10% to 43% and 0% to 17% of the total, respectively.

## 4.3 Suspended Sediment Transport Regime

### 4.3.1 Annual Suspended Sediment Regime: Daily Data

Annual flow and suspended sediment concentration for each of the nine years of continuous record are shown in Figures 16-18. These hydrographs show typical Prairie hydrologic characteristics with a dominant March-April high flow period arising from snow melt runoff. This flow event is evident in all years except 1981. Secondary flow peaks can occur in June and July, and smaller ones in the August-October period. The range of the March-April peaks are 107 - 2 620 $m^3/s$, and are generally representative of the historic flows.

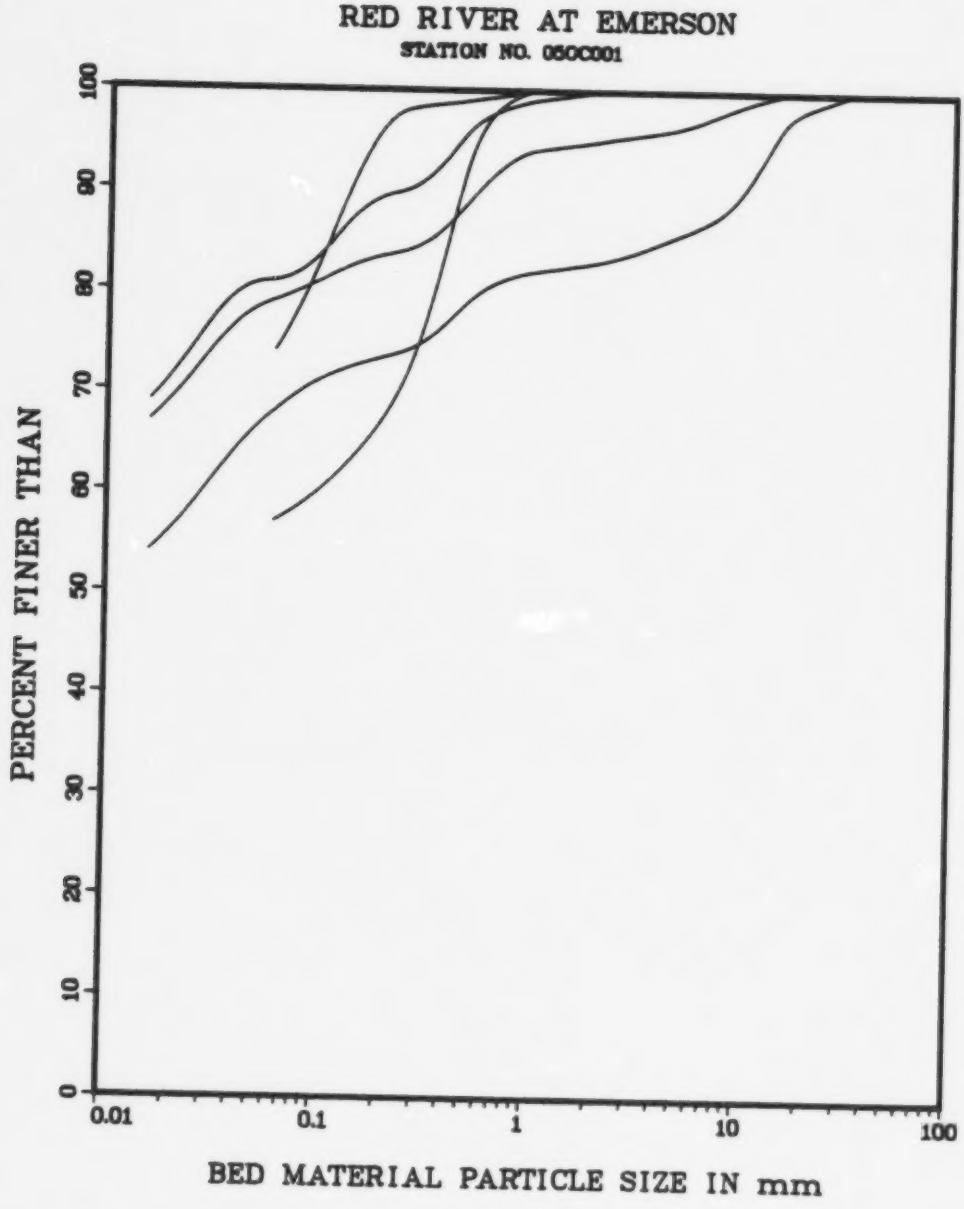
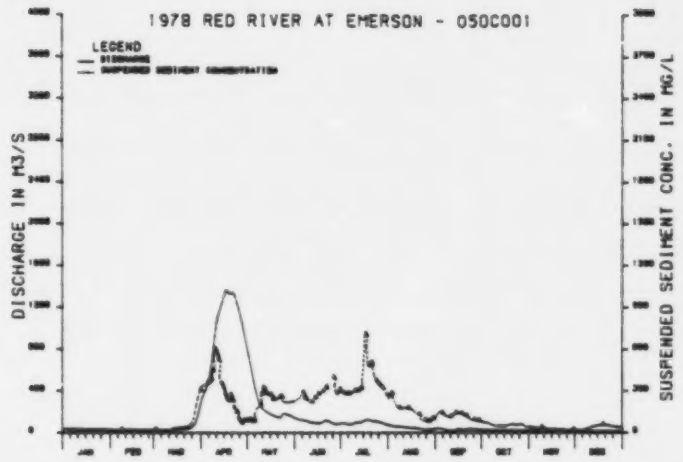
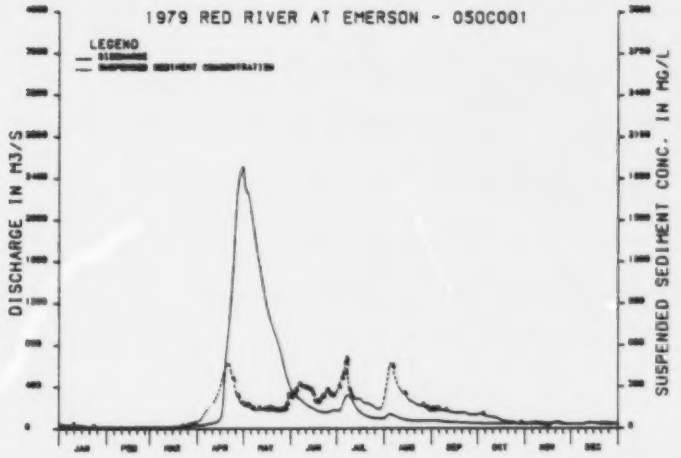



Figure 15. Bed Material Data



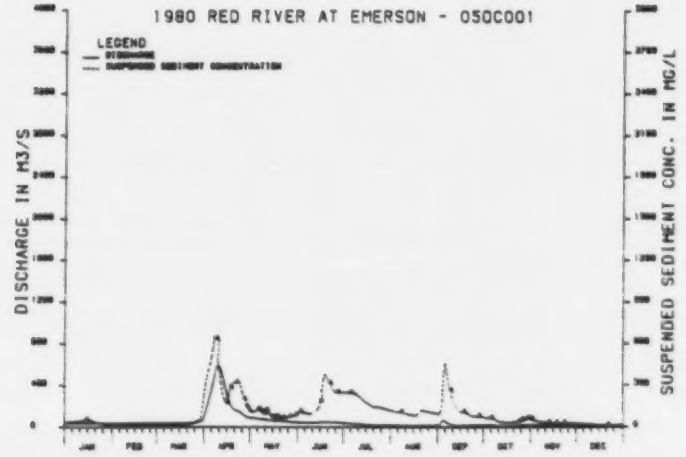
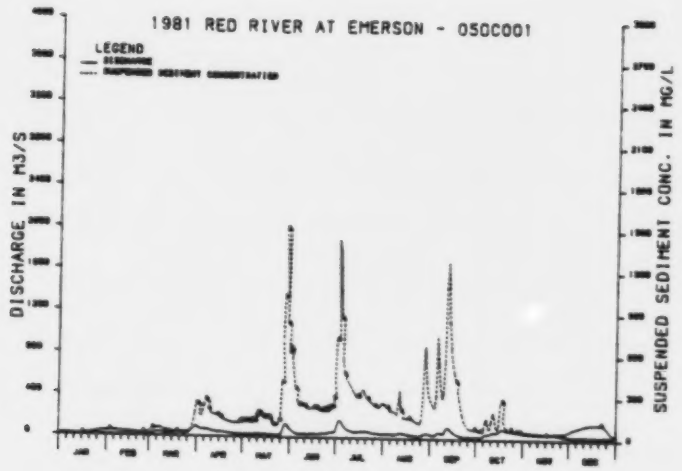
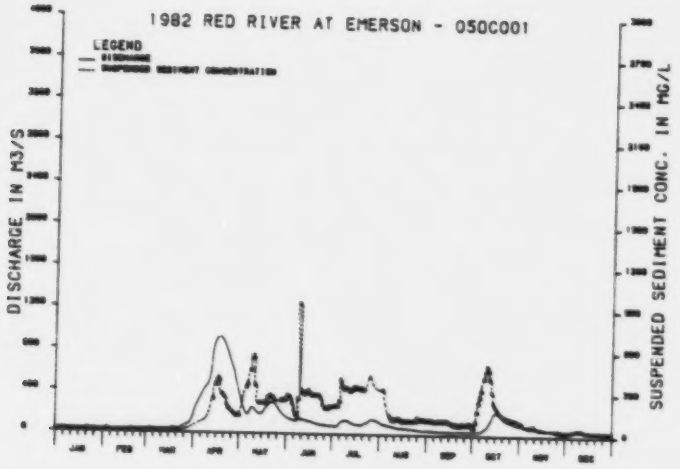




**Figure 16. Discharge Hydrograph and Suspended Sediment Concentration Curve for Individual Years, 1978-1980**



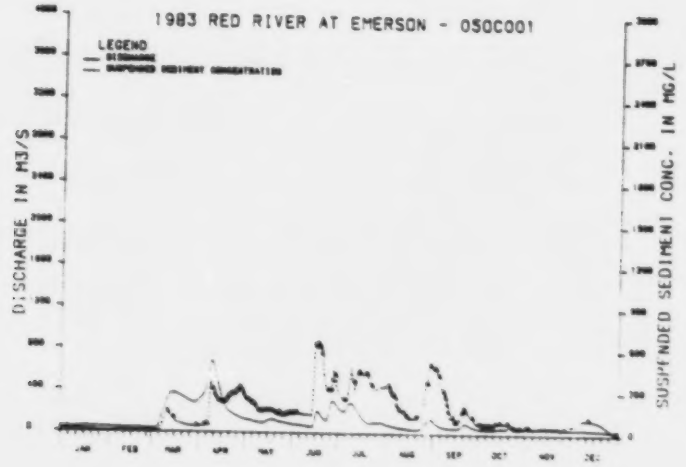
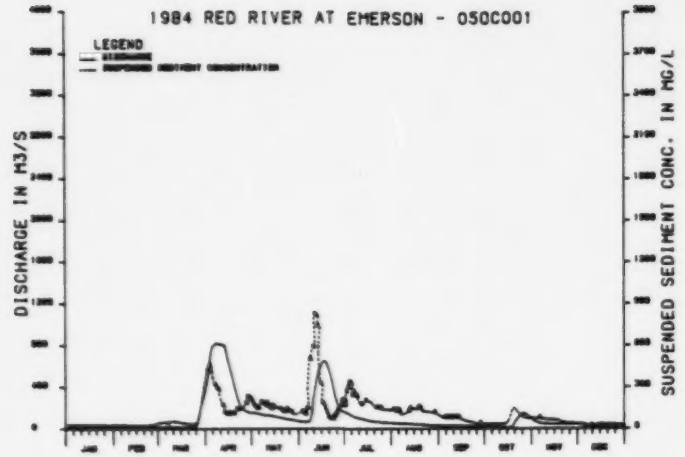
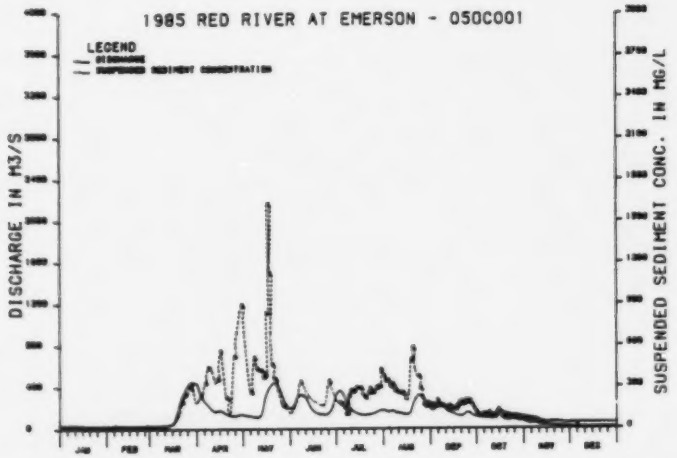




**Figure 17. Discharge Hydrograph and Suspended Sediment Concentration Curve for Individual Years, 1981-1983**



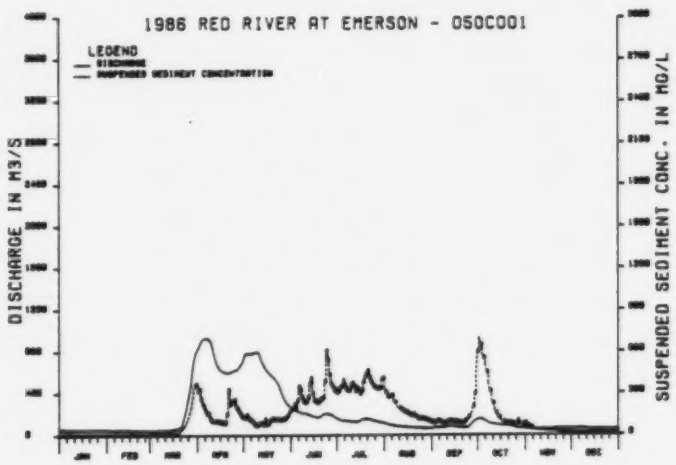




**Figure 18. Discharge Hydrograph and Suspended Sediment Concentration Curve for Individual Years, 1984-1986**

The annual suspended sediment regime also follows a systematic pattern. The first rise in concentration generally comes with or just slightly before the beginning of the spring runoff period. Peak concentrations during this period typically range from 400 mg/L to 800 mg/L. While this spring period may possess the peak annual concentration, these normally occur during the May-August period. During these months, concentrations are highest and concentration peaks occur when flows increase from rainfall runoff. However, several concentration peaks occur without any concurrent increase in flow (e.g., June 1980, April 1985). During this May-August period the record peak concentration of 1 930 mg/L occurred on May 17, 1985. Generally, peaks range from 300 mg/L to 1 900 mg/L.

The complexities of these concentration-discharge relations are illustrated more directly in Figures 19 and 20, where daily rating plots for 1978 and 1981 are shown. In 1978, a "typical" year, the overall relationship shows a counter-clockwise hysteresis pattern. This is generally valid for the whole year and in particular, in early April. However, there are deviations from this general pattern, such as the latter half of April and the August-September period when clockwise hysteresis is evident. The peak concentration event occurred during the counter-clockwise period and is clearly seen in the plotted data. The concentration-discharge pattern for 1981 shows hysteresis, but the general pattern is not so clear as the spring event was very small.

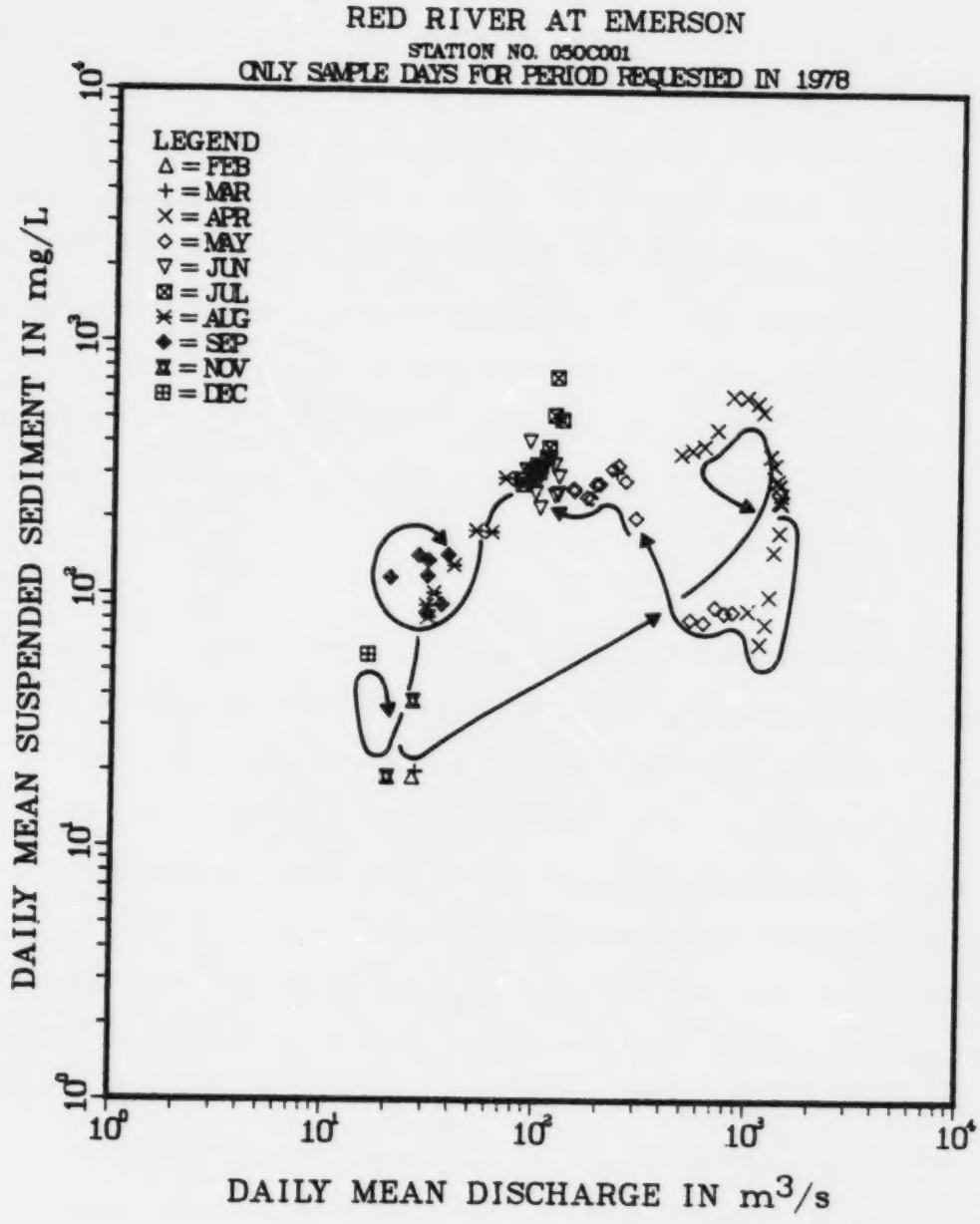



**Figure 19. Rating Relationship for Daily Mean Suspended Sediment Concentration Versus Daily Mean Discharge for 1978**

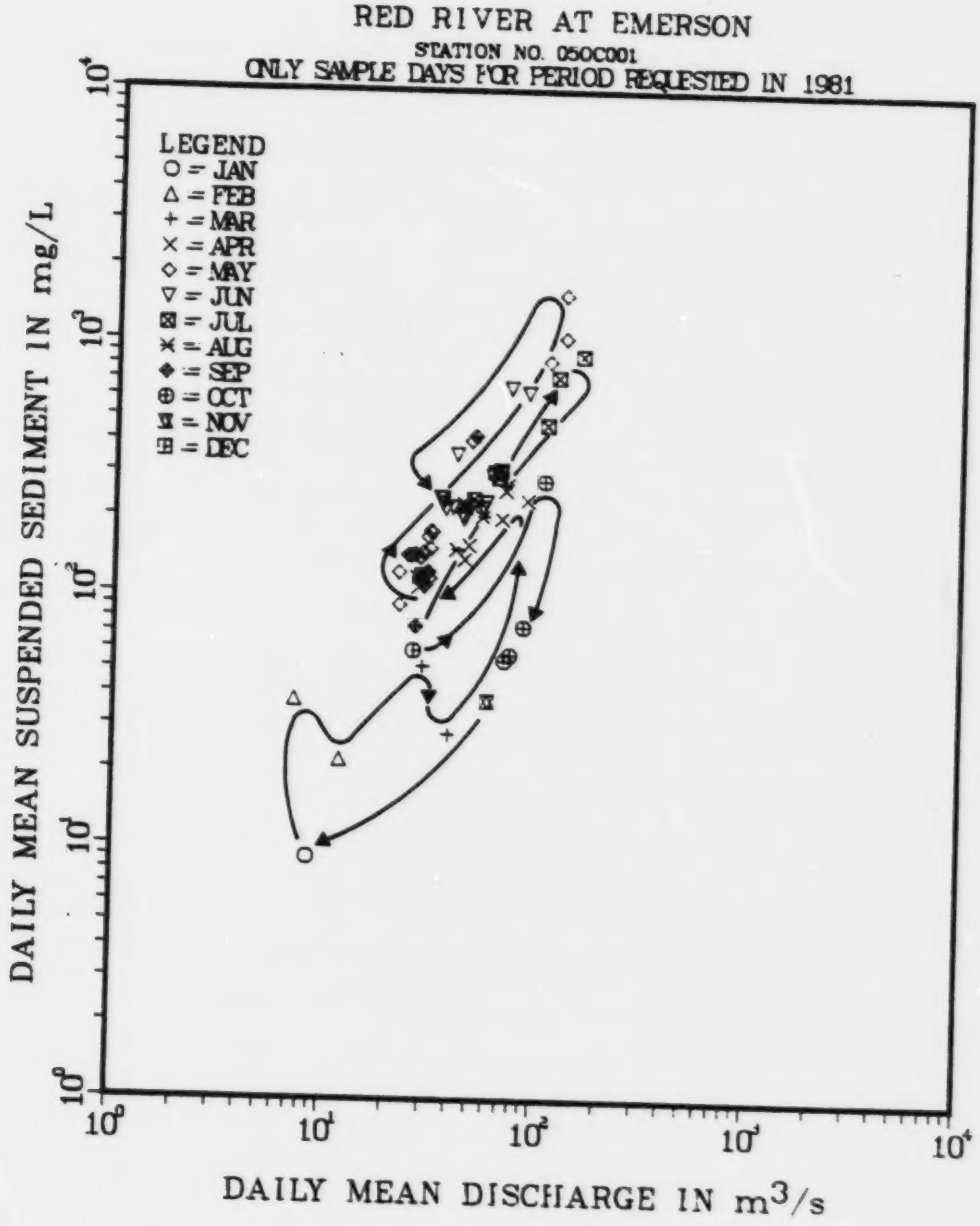



**Figure 20. Rating Relationship for Daily Mean Suspended Sediment Concentration Versus Daily Mean Discharge for 1981**

### 4.3.2 Annual Regime: Monthly Data

Figure 21 shows the relationship between mean monthly total suspended load and mean monthly total discharge for the period 1978-1986. The plot also reveals that counter-clockwise hysteresis exists. This counter-clockwise hysteresis is opposite to the pattern exhibited by most rivers (Ashmore, 1986). Similar plots for the individual years (Figure 22-24), reveal that the trend is present for all years except 1981 and 1985. A counter-clockwise hysteresis pattern reveals that the suspended sediment concentration will peak after peak discharge. Figures 16-18 confirm this interpretation. These plots show that summer concentrations tend to be higher than spring concentrations. This trend exists even though summer flows are lower than spring flows. The net result is that significant amounts of the yearly load can be transported during the summer months. Figure 23 shows the plot of mean monthly total suspended load versus mean monthly total discharge at the Red River near Ste. Agathe station, for the period 1962-1978. The plot reveals that a counter-clockwise hysteresis also exists at this location, which is 65 km downstream from Emerson. This suggests that the trend exists for at least the lower portion of the Red River.

A possible explanation of the counter-clockwise hysteresis lies in the nature of the material being transported. As shown in Section 4.2, the suspended sediment always consisted of over 90% silt and clay. Therefore, sediment yield for the Red River must be dependent on the

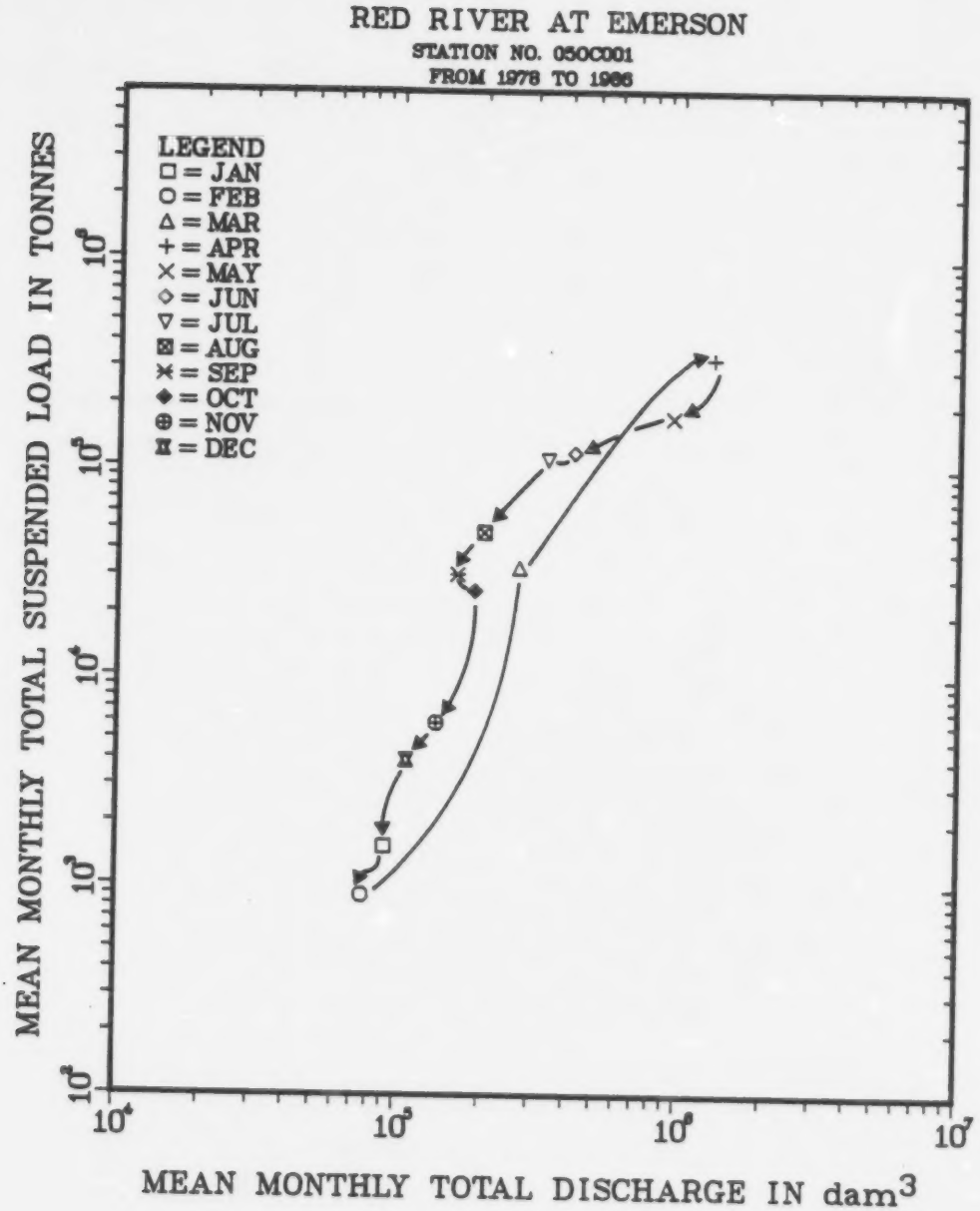



**Figure 21. Mean Monthly Total Load Versus Mean Monthly Discharge for 1978 to 1986 Showing Hysteresis**

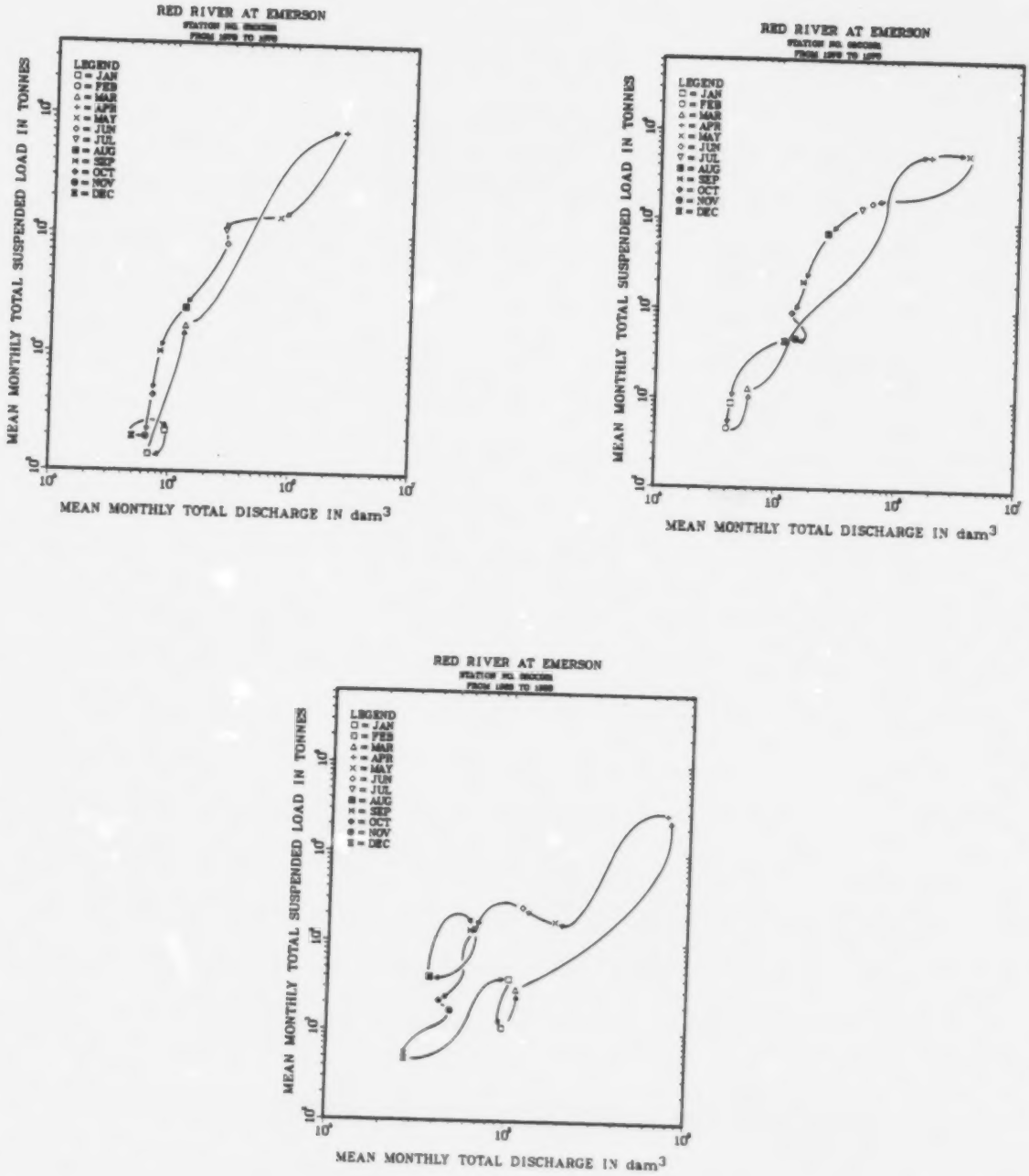
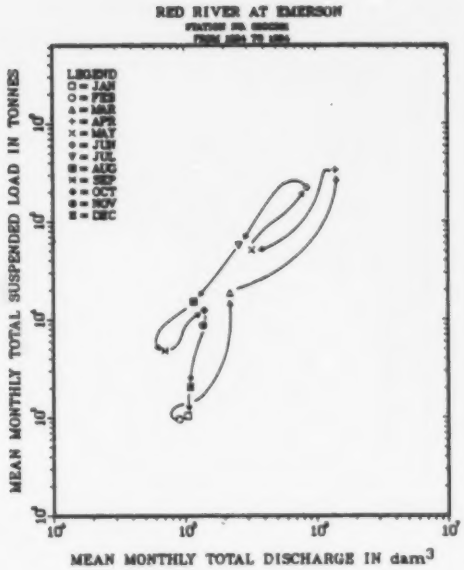
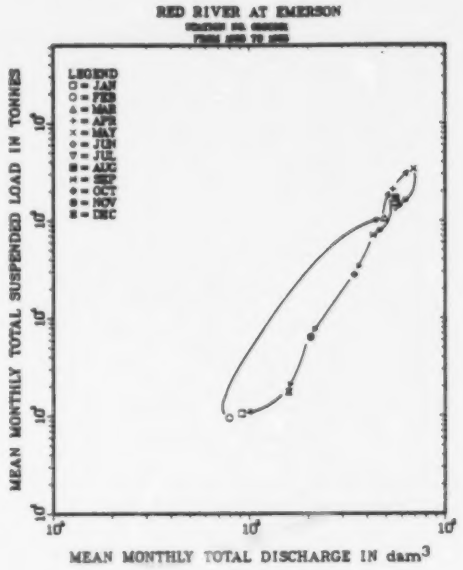



**Figure 22. Rating Relationship for Mean Monthly Total Load Versus Mean Discharge for Individual Years, 1978-1980**

Figure 23. Rating Relationship for Mean Monthly Total Load Versus Mean Discharge for Individual Years, 1981-1983



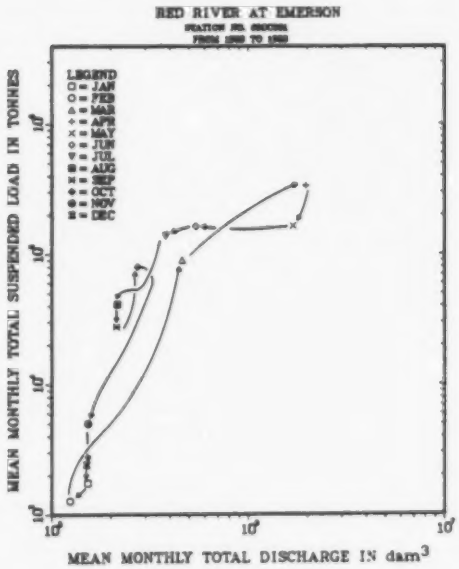




**Figure 24. Rating Relationship for Mean Monthly Total Load Versus Mean Discharge for Individual Years, 1984-1988**

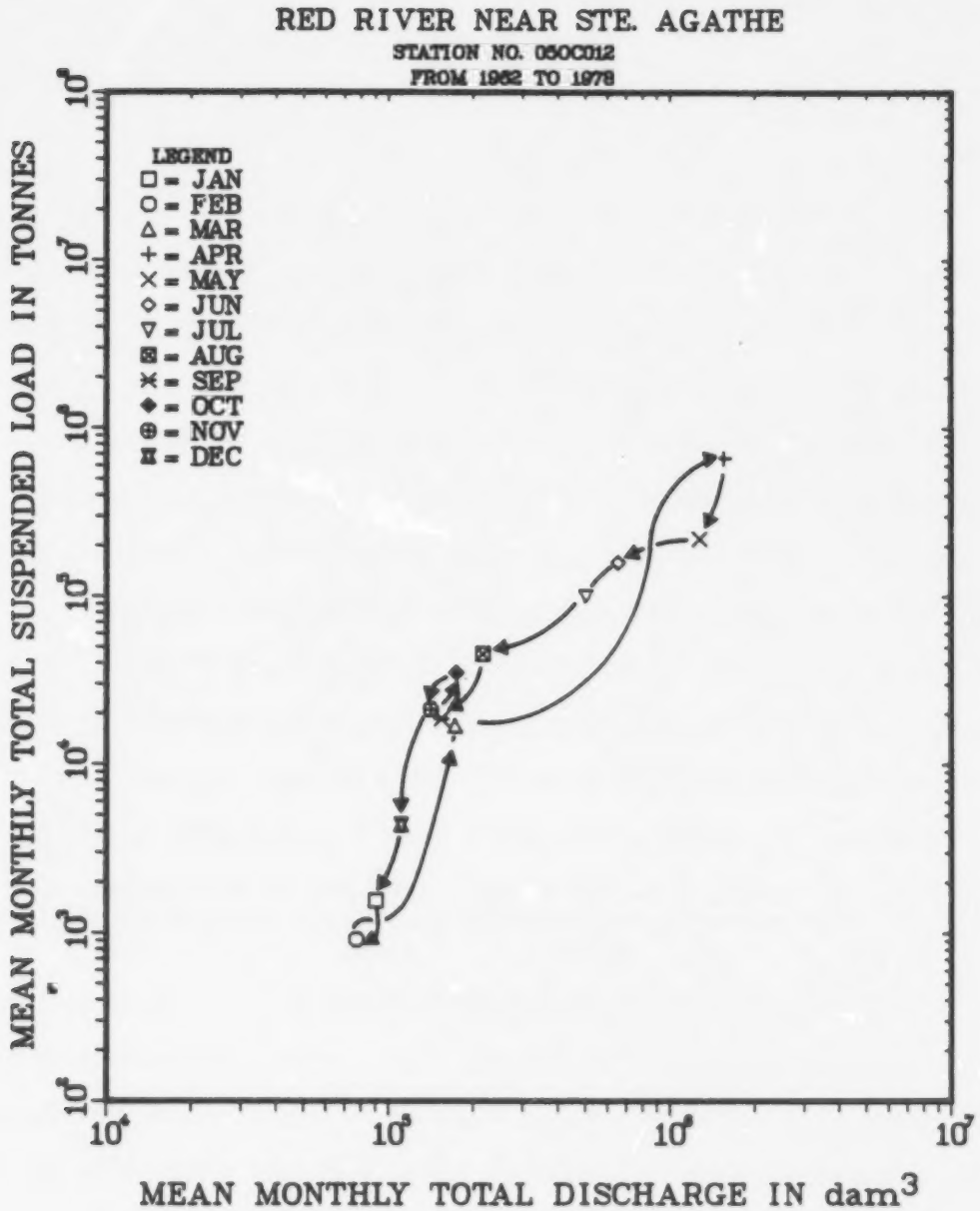



**Figure 25.** Mean Monthly Total Load Versus Mean Monthly Discharge for the Red River at Ste. Agathe Station (1962-1978)

availability of material, rather than on the hydraulic capacity of the river. Availability of sediment material is dependent upon a number of factors including land use and supply processes.

### 4.3.3 Annual Load

The Red River can transport a large percentage of its annual sediment load in a relatively short period of time. Figure 26 illustrates the significance of various periods of transport. Suspended sediment load being transported in 1% and 10% of the year (i.e. 4 days and 37 days) are compared to the total yearly load. The figure shows that within a 37 day period, between 33% and 79% of the yearly load is transported. Similarly, within a 4 day period between 10% and 30% of the yearly load is transported. Although these figures are moderate (compared to flashier rivers), they are still very significant. Table 8 shows that on average, 51% of the annual load is transported in a 37 day period, commencing in March or April. Table 9 shows that during the April-October period 95% of the yearly load is transported. Also, during the June-September period, 35% of the yearly load is transported.

Since 1978 approximately 8 million tonnes of suspended sediments have been transported past the Emerson site. Annual loads vary from 372 000 tonnes to 1.5 million tonnes. As shown in Figures 27 and 28, there is a consistent relationship between annual loads and annual flow volumes.

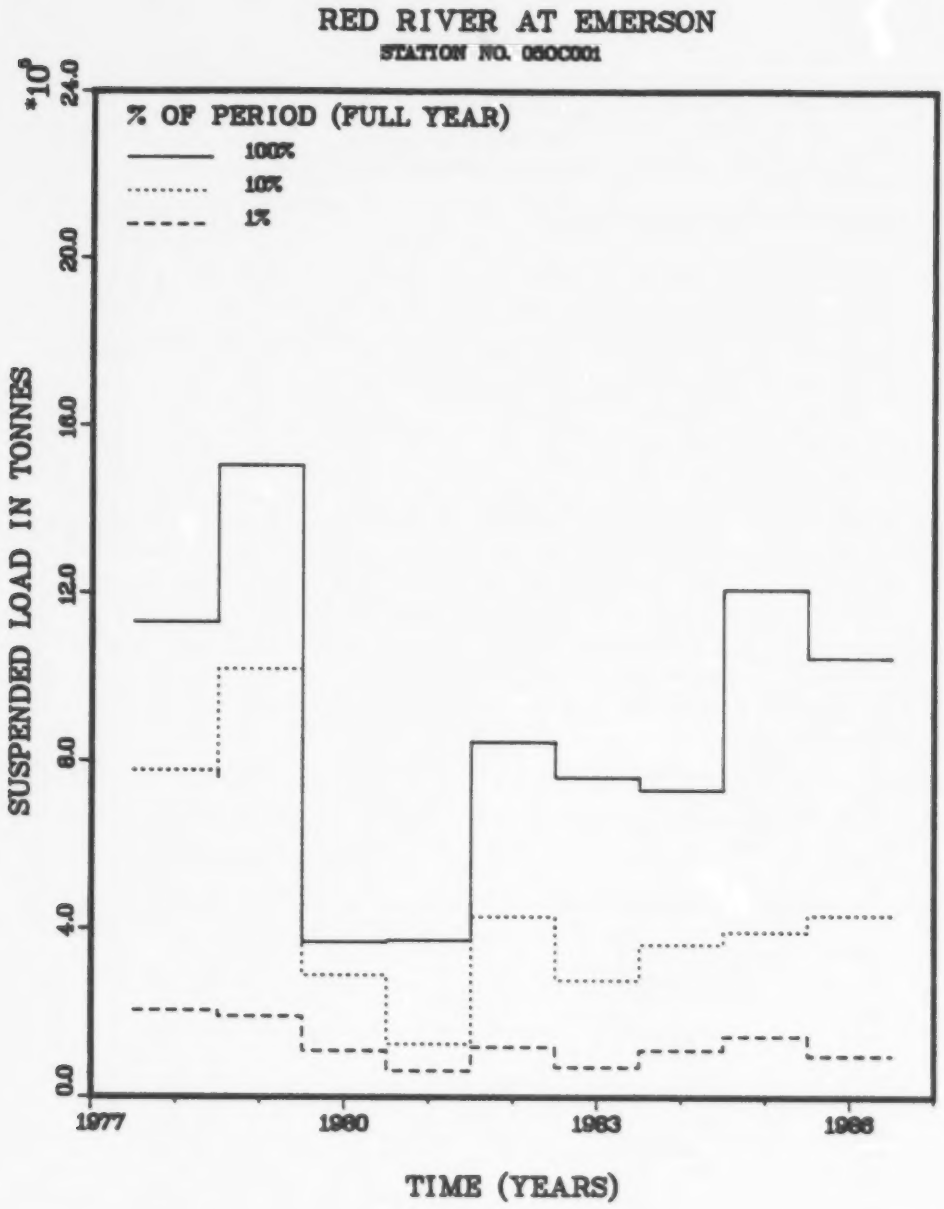



Figure 26. Sediment Load Transported During 1%, 10% and 100% of Year

Table 8. Sediment Loading During 1%, 10% and 100% of Year

| Year | Yearly Load (tonnes) | Best 10% of Period: Starting Date | Best 10% of Period: Load (tonnes) | Best 10% of Period: % of yearly load | Best 1% of Period: Starting Date | Best 1% of Period: Load (tonnes) | Best 1% of Period: % of yearly date |
|---|---|---|---|---|---|---|---|
| 1978 | 1 129 972 | Mar. 19 | 777 080 | 69 | Apr. 9 | 206 000 | 18 |
| 1979 | 1 504 263 | Apr. 17 | 1 019 300 | 68 | Apr. 24 | 192 000 | 13 |
| 1980 | 369 019 | Mar. 20 | 289 915 | 79 | Apr. 7 | 110 800 | 30 |
| 1981 | 372 431 | May 28 | 126 209 | 34 | Jul. 2 | 62 660 | 17 |
| 1982 | 846 216 | Apr. 8 | 429 520 | 51 | Apr. 15 | 119 100 | 14 |
| 1983 | 761 824 | Jun. 15 | 278 020 | 37 | Apr. 9 | 71 800 | 9 |
| 1984 | 732 136 | Mar. 17 | 363 050 | 50 | Jun. 11 | 112 400 | 15 |
| 1985 | 1 209 956 | Apr. 23 | 392 980 | 33 | May 16 | 145 300 | 12 |
| 1986 | 1 046 658 | Mar. 16 | 433 260 | 41 | Mar. 19 | 98 800 | 9 |
| | | | | Mean 51 | | | |

Table 9. Mean Monthly Proportion of Total Annual Load (1978-1986)

| Month | Load | % of Total Load |
|---|---|---|
| Jan. | 1536 | 0.17 |
| Feb. | 894 | 0.10 |
| Mar. | 33 113 | 3.74 |
| Apr. | 333 695 | 37.67 |
| May | 174 197 | 19.66 |
| Jun. | 118 126 | 13.34 |
| Jul. | 109 276 | 12.34 |
| Aug. | 48 657 | 5.49 |
| Sept. | 30 717 | 3.47 |
| Oct. | 25 625 | 2.89 |
| Nov. | 6 006 | 0.68 |
| Dec. | 3 988 | 0.45 |
| | 885 830 | 100 |

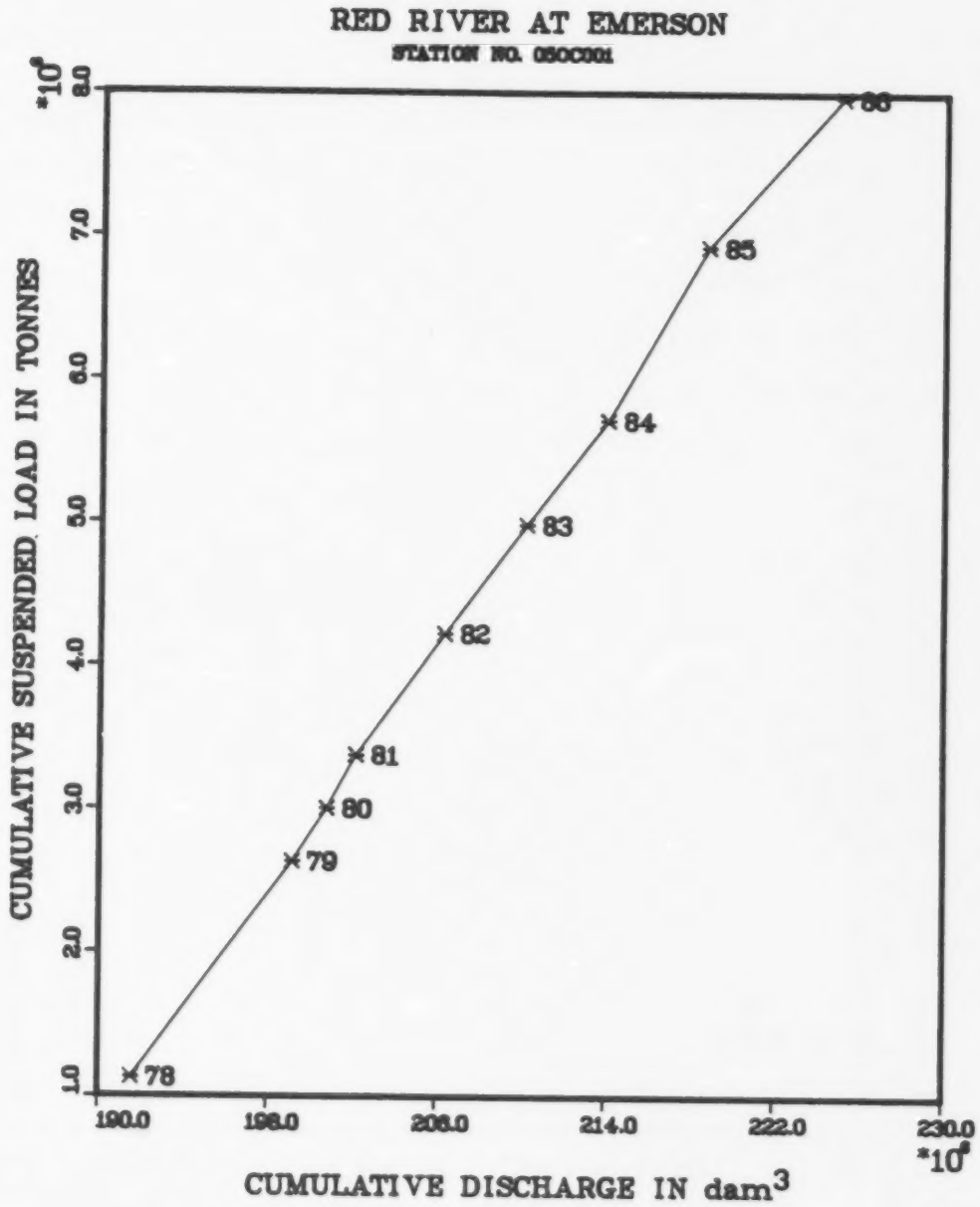



Figure 27. Cumulative Plot of Suspended Load Versus Discharge for the Period 1978 to 1986

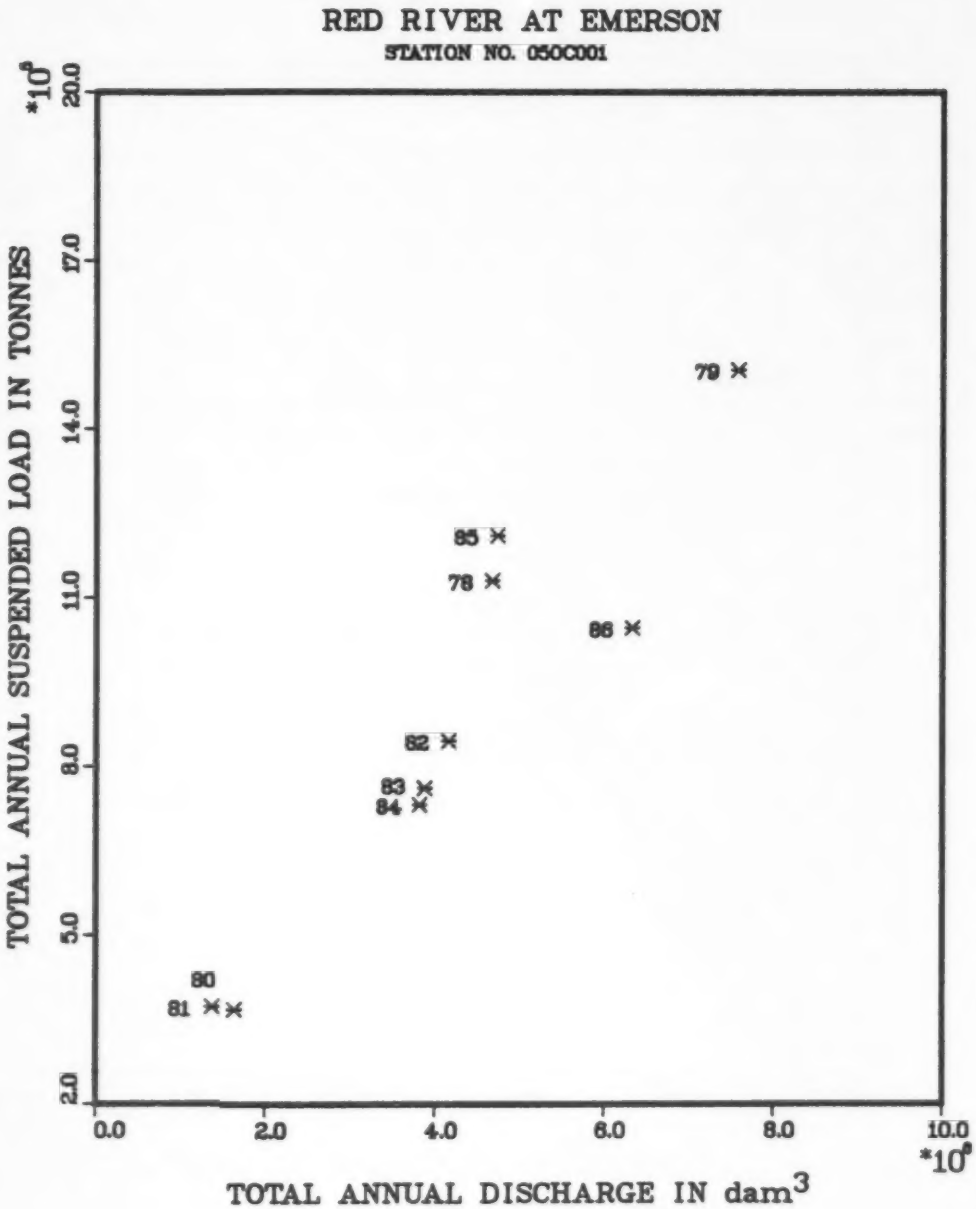



Figure 28. Relationship Between Annual Load and Annual Discharge

### 4.3.4 Mean Characteristics

The short period of record affects the precision of the long-term estimates of the mean conditions for concentration and load. The relationship between the standard error estimate for the mean annual concentration and the record length is shown in Figure 29. A similar diagram for the mean annual load is in Figure 30. After nine years of record, the standard error of the mean concentration has been reduced to about 7%. However, for the mean load, the standard error has not become asymptotic about any value. Presently, the percent gain in the standard error of the mean load, for each additional year of record, is about 2%. Therefore a few more years of data will help improve the estimate of the long term mean sediment load.

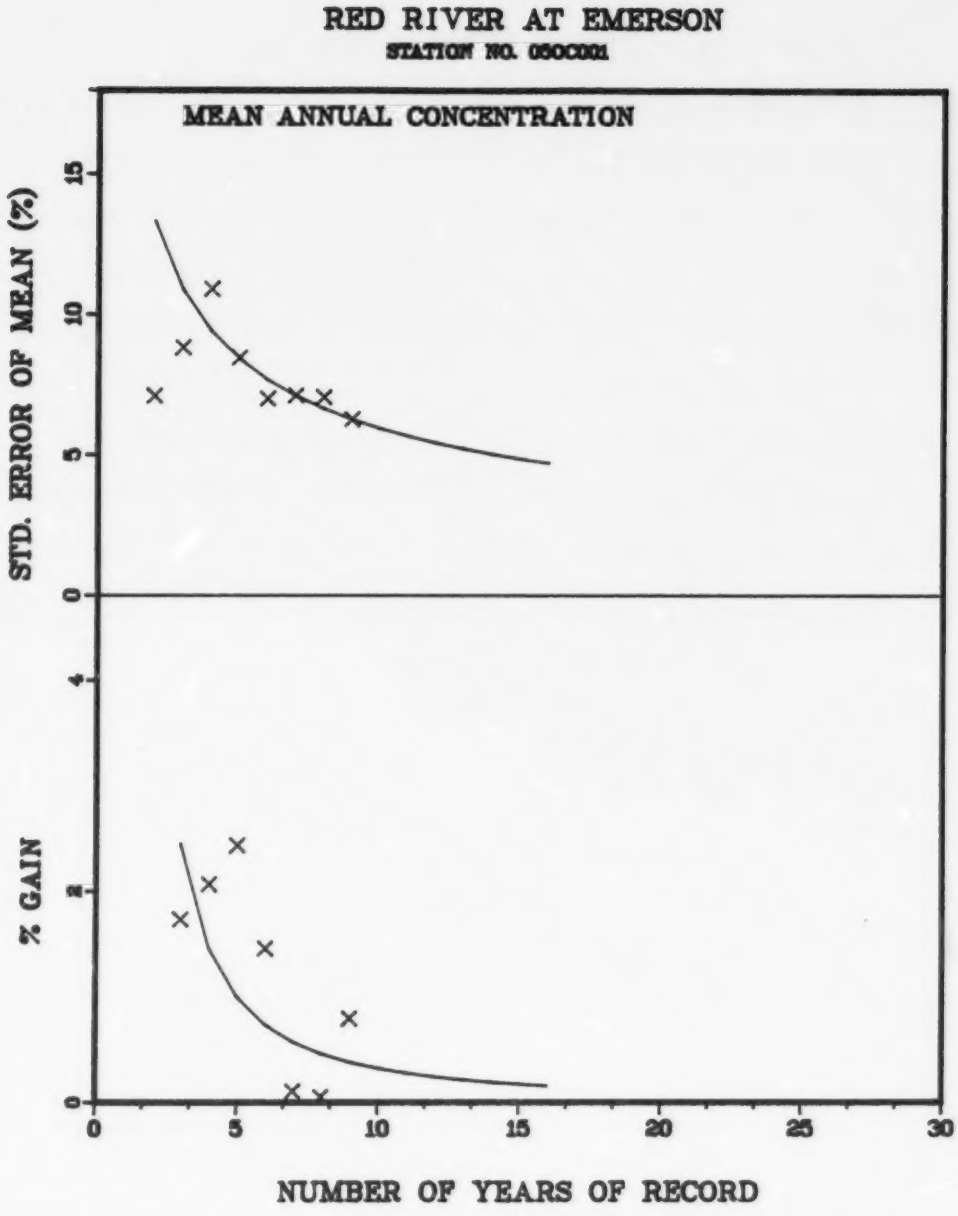



Figure 29. Realtionship Between the Standard Error of Annual Suspended Sediment Concentration and Record Length

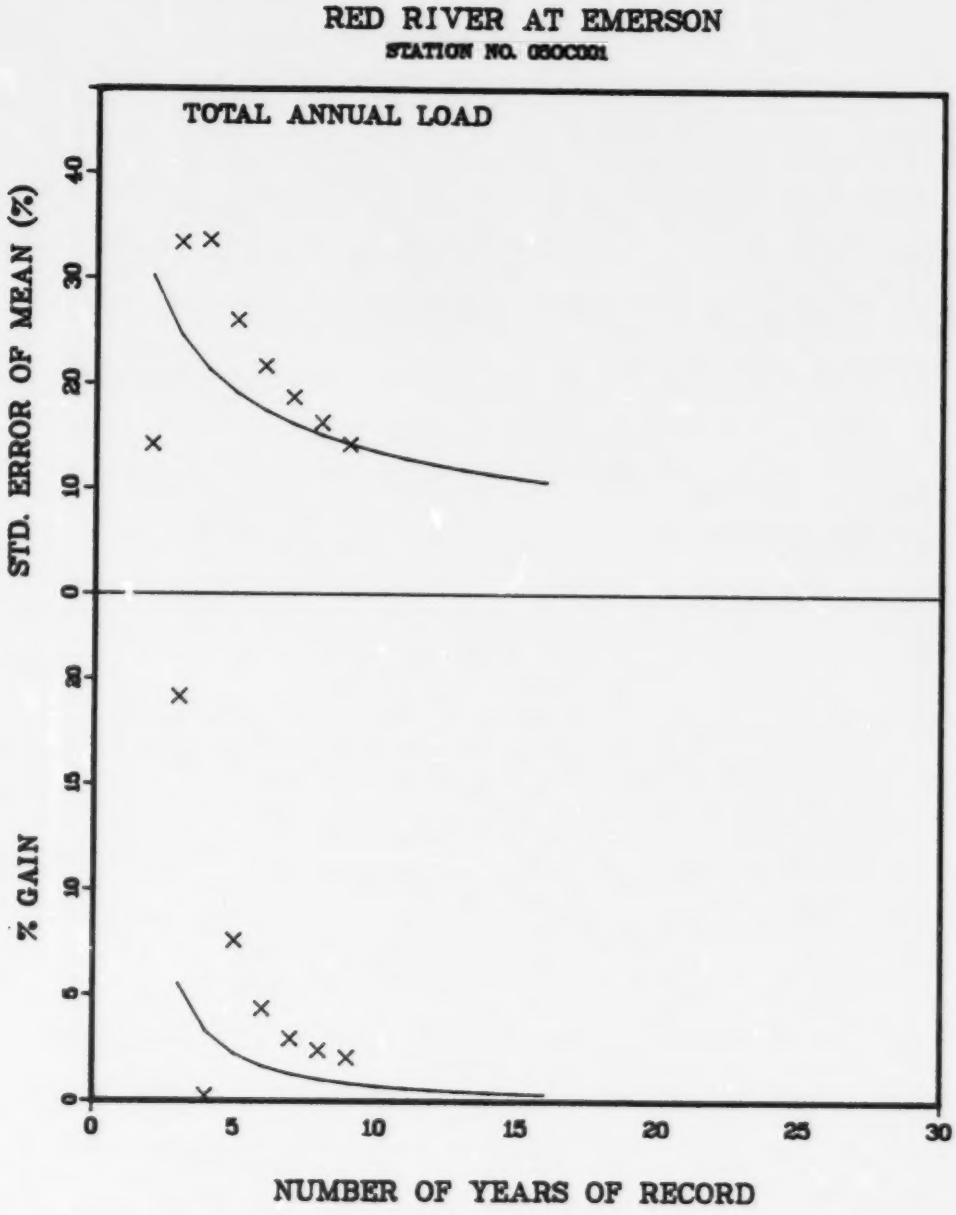



Figure 30. Relationship Between the Standard Error of Annual Suspended Sediment Load and Record Length

## 5. Summary

Adequate data presently exist to define the suspended sediment transport regime at the Red River at Emerson site. While only nine years of record exist these are sufficient to indicate what seasonal and annual variations in concentration can be expected. The range in the data (annual maximum and total annual discharge) are good, with extremes occurring in 1979 and 1981.

The suspended sediments are primarily silt and clay. Particle size characteristics show no relationship to hydraulics. Cross-sectional variations are minor and there are not any seasonal trends in particle sizes of the suspended sediment.

An evaluation of data collected by Water Survey of Canada and the United States Geological Survey indicated that they are compatible. This is due to the fact that the suspended sediment is well mixed and primarily made up of fines.

The most interesting aspect of these data is the existence of counter-clockwise hysteresis in the concentration-discharge rating plots. The causes of these elevated concentrations of suspended sediments during summer months are unknown and need to be investigated.

Specific recommendation for the WSC program are:

1. Terminate the K-factor program as the single vertical results are sufficiently representative of cross-sectional average concentrations;

2. Efforts should be made to co-ordinate WSC and USGS sampling activities in order to provide further comparative data;

3. Similarly in order to provide data for comparisons between WSC and Water Quality Branch programs, coordination of their field sampling activities should be pursued; and,

4. Finally, the sampling program can be cut back to 50-100 samples per year, and spaced so that Recommendations 2 and 3 are addressed and the peak discharge is covered.

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# APPENDIX A

## EXAMPLE OUTPUTS OF

## WATER SURVEY OF CANADA PUBLISHED DATA

MANITOBA

RED RIVER AT EMERSON - STATION NO 05OC001

SUSPENDED SEDIMENT FOR 1985

LOCATION: LAT 49 00 30 N LONG 97 12 40 W
DRAINAGE AREA: 104 000 km²
TYPE OF FLOW: REGULATED
TYPE OF GAUGE: RECORDING

INTERNATIONAL GAUGING STATION

TOTAL SUSPENDED SEDIMENT LOAD : 210 000 TONNES FOR THE PERIOD JAN 01 TO DEC 31

REMARKS

| DAY | JAN DAILY DISCHARGE (m³/s) | JAN MEAN CONCENTRATION (mg/L) | JAN DAILY LOAD (t) | FEB DAILY DISCHARGE (m³/s) | FEB MEAN CONCENTRATION (mg/L) | FEB DAILY LOAD (t) | MAR DAILY DISCHARGE (m³/s) | MAR MEAN CONCENTRATION (mg/L) | MAR DAILY LOAD (t) | DAY |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 36.0 B | 12 | 36.3 | 32.4 B | 12 | 33.8 | 35.0 B | 12 | 36.3 | 1 |
| 2 | 36.6 B | 12 | 37.8 | 32.4 B | 12 | 33.6 | 36.3 B | 10 | 30.5 | 2 |
| 3 | 36.3 B | 12 | 37.8 | 32.3 B | 12 | 33.6 | 36.5 B | 10 | 30.7 | 3 |
| 4 | 36.0 B | 12 | 37.3 | 32.2 B | 12 | 33.4 | 36.6 B | 10 | 30.8 | 4 |
| 5 | 35.7 B | 11 | 33.9 | 32.1 B | 13 | 36.1 | 36.2 B | 8 | 25.0 | 5 |
| 6 | 35.4 B | 11 | 33.6 | 32.0 B | 13 S | 35.9 | 36.0 B | 9 | 28.7 | 6 |
| 7 | 35.1 B | 11 | 33.4 | 32.2 B | 13 | 36.2 | 37.8 B | 11 | 35.9 | 7 |
| 8 | 34.8 B | 11 S | 33.1 | 32.1 B | 13 | 36.1 | 38.5 B | 13 | 38.8 | 8 |
| 9 | 34.7 B | 11 | 33.0 | 32.1 B | 13 | 36.1 | 39.0 B | 11 | 37.1 | 9 |
| 10 | 34.6 B | 11 | 32.9 | 32.1 B | 13 | 36.1 | 38.8 B | 11 | 37.0 | 10 |
| 11 | 34.5 B | 11 | 32.8 | 32.3 B | 13 | 36.2 | 38.2 B | 10 | 33.0 | 11 |
| 12 | 34.4 B | 11 | 32.7 | 32.2 B | 13 | 36.2 | 38.7 B | 13 | 43.5 | 12 |
| 13 | 34.3 B | 11 | 32.6 | 32.3 B | 12 | 33.8 | 41.7 B | 23 | 82.9 | 13 |
| 14 | 34.2 B | 11 | 32.5 | 32.4 B | 12 | 33.8 | 44.4 B | 34 | 130 | 14 |
| 15 | 34.1 B | 11 | 32.4 | 33.6 B | 12 | 33.8 | 47.0 B | 37 | 150 | 15 |
| 16 | 34.0 B | 11 | 32.3 | 32.5 B | 12 | 33.7 | 53.2 B | 38 | 175 | 16 |
| 17 | 33.9 B | 11 | 32.3 | 32.5 B | 12 | 33.7 | 70.9 B | 46 | 282 | 17 |
| 18 | 33.6 B | 11 | 32.1 | 32.7 B | 12 | 33.8 | 108 B | 84 | 587 | 18 |
| 19 | 33.7 B | 12 | 34.8 | 32.8 B | 12 | 34.0 | 187 B | 80 | 1 090 | 19 |
| 20 | 33.6 B | 12 | 34.6 | 32.7 B | 12 | 33.8 | 214 B | 101 | 1 870 | 20 |
| 21 | 33.5 B | 12 | 34.7 | 32.7 B | 12 | 33.8 | 273 B | 129 | 3 040 | 21 |
| 22 | 33.4 B | 12 | 34.6 | 32.6 B | 11 | 31.2 | 314 B | 193 S | 5 240 | 22 |
| 23 | 33.3 B | 12 | 34.5 | 32.9 B | 11 | 31.3 | 347 B | 236 | 7 080 | 23 |
| 24 | 33.3 B | 12 | 34.4 | 33.0 B | 11 | 31.4 | 378 B | 247 S | 8 000 | 24 |
| 25 | 33.1 B | 12 | 34.3 | 33.4 B | 11 | 31.7 | 407 B | 257 | 9 040 | 25 |
| 26 | 33.0 B | 12 | 34.2 | 33.9 B | 11 | 32.2 | 427 B | 270 | 10 200 | 26 |
| 27 | 32.8 B | 12 | 34.1 | 34.3 B | 11 S | 32.5 | 443 B | 301 S | 12 000 | 27 |
| 28 | 32.6 B | 12 | 34.0 | 34.7 B | 11 | 33.0 | 460 B | 332 | 13 500 | 28 |
| 29 | 32.7 B | 12 | 33.9 | | | | 472 B | 340 | 13 900 | 29 |
| 30 | 32.6 B | 12 | 33.8 | | | | 469 B | 274 | 11 100 | 30 |
| 31 | 32.5 B | 12 | 33.7 | | | | 463 B | 306 | 8 240 | 31 |
| TOTAL | 1 059.5 | | 1 059.5 | 914.5 | | 950.6 | 5 670 0 | | 108 135.4 | TOTAL |

| DAY | APR DAILY DISCHARGE (m³/s) | APR MEAN CONCENTRATION (mg/L) | APR DAILY LOAD (t) | MAY DAILY DISCHARGE (m³/s) | MAY MEAN CONCENTRATION (mg/L) | MAY DAILY LOAD (t) | JUN DAILY DISCHARGE (m³/s) | JUN MEAN CONCENTRATION (mg/L) | JUN DAILY LOAD (t) | DAY |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 456 B | 195 | 7 840 | 143 | 647 | 10 500 | 303 | 118 | 2 070 | 1 |
| 2 | 424 B | 217 | 7 950 | 140 | 705 | 8 530 | 296 | 122 | 2 170 | 2 |
| 3 | 373 | 236 S | 7 700 | 138 | 567 | 6 660 | 324 | 148 | 3 830 | 3 |
| 4 | 329 | 243 | 6 910 | 133 | 451 | 5 180 | 346 | 172 | 5 680 | 4 |
| 5 | 304 | 271 | 7 130 | 131 | 348 | 3 920 | 300 | 300 | 5 180 | 5 |
| 6 | 293 | 337 S | 8 210 | 135 | 388 S | 3 940 | 328 | 249 | 7 010 | 6 |
| 7 | 263 | 387 | 8 020 | 134 | 338 | 3 620 | 336 | 328 | 9 530 | 7 |
| 8 | 246 | 453 S | 8 610 | 131 | 530 S | 5 840 | 341 | 372 | 11 000 | 8 |
| 9 | 228 | 472 | 8 300 | 119 | 536 | 5 480 | 338 | 351 | 10 300 | 9 |
| 10 | 210 | 488 | 8 910 | 118 | 448 S | 4 480 | 333 | 318 | 9 090 | 10 |
| 11 | 195 | 436 | 7 380 | 118 | 437 | 4 450 | 317 | 289 | 7 930 | 11 |
| 12 | 181 | 394 | 6 180 | 124 | 444 | 4 760 | 282 | 286 | 6 780 | 12 |
| 13 | 176 | 348 | 5 260 | 140 | 429 S | 5 190 | 269 | 248 | 5 600 | 13 |
| 14 | 181 | 385 S | 5 710 | 158 | 383 S | 6 110 | 238 | 232 | 4 530 | 14 |
| 15 | 185 | 458 | 7 460 | 286 | 396 S | 9 150 | 301 | 333 | 8 670 | 15 |
| 16 | 187 | 574 S | 9 270 | 330 | 881 S | 24 600 | 183 | 210 | 3 320 | 16 |
| 17 | 183 | 678 | 9 110 | 372 | 1 030 S | 34 000 | 170 | 205 | 3 010 | 17 |
| 18 | 178 | 662 | 8 890 | 403 | 1 160 S | 40 400 | 160 | 202 | 2 790 | 18 |
| 19 | 183 | 380 | 4 930 | 428 | 713 | 26 400 | 184 | 181 | 3 540 | 19 |
| 20 | 183 | 226 S | 3 010 | 448 | 676 S | 16 500 | 149 | 161 | 2 330 | 20 |
| 21 | 168 | 158 | 2 C | 480 | 387 | 15 400 | 147 | 180 | 2 290 | 21 |
| 22 | 140 | 123 | 1 490 | 487 | 366 S | 14 800 | 146 | 177 | 2 230 | 22 |
| 23 | 135 | 135 | 1 480 | 458 | 335 | 13 300 | 163 | 176 | 2 170 | 23 |
| 24 | 131 | 274 | 3 150 | 438 | 294 | 11 200 | 161 | 201 | 2 450 | 24 |
| 25 | 126 | 537 S | 5 940 | 410 | 295 | 9 030 | 168 | 270 | 3 410 | 25 |
| 26 | 130 | 640 | 7 190 | 369 | 210 | 6 700 | 183 | 350 S | 4 630 | 26 |
| 27 | 136 | 723 | 8 500 | 335 | 184 S | 4 850 | 183 | 338 | 4 930 | 27 |
| 28 | 142 | 800 | 9 420 | 283 | 167 S | 4 080 | 193 | 310 | 5 140 | 28 |
| 29 | 148 | 876 | 11 000 | 251 | 159 | 3 450 | 233 | 273 | 5 500 | 29 |
| 30 | 145 | 919 S | 11 500 | 227 | 149 | 2 920 | 283 | 245 | 6 180 | 30 |
| 31 | | | | 211 | 134 | 2 440 | | | | 31 |
| TOTAL | 6 273 | | 208 500 | 6 007 | | 336 330 | 6 740 | | 144 520 | TOTAL |

B - ICE CONDITIONS

S - SAMPLE(S) COLLECTED THIS DAY

RED RIVER AT EMERSON - STATION NO. 05OC001

SUSPENDED SEDIMENT FOR 1985

| DAY | JUL DAILY DISCHARGE ($m^3/s$) | JUL MEAN CONCENTRATION (mg/L) | JUL DAILY LOAD (t) | AUG DAILY DISCHARGE ($m^3/s$) | AUG MEAN CONCENTRATION (mg/L) | AUG DAILY LOAD (t) | SEP DAILY DISCHARGE ($m^3/s$) | SEP MEAN CONCENTRATION (mg/L) | SEP DAILY LOAD (t) | DAY |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 339 | 217 | 6 380 | 188 | 387 S | 5 220 | 198 | 183 S | 3 790 | 1 |
| 2 | 365 | 187 | 5 210 | 163 | 350 S | 5 530 | 183 | 189 S | 3 870 | 2 |
| 3 | 380 | 167 S | 5 140 | 175 | 376 | 5 720 | 183 | 183 S | 2 980 | 3 |
| 4 | 361 | 176 S | 5 850 | 171 | 351 S | 5 180 | 188 | 154 S | 2 700 | 4 |
| 5 | 385 | 176 S | 5 520 | 186 | 313 S | 4 480 | 217 | 201 S | 3 770 | 5 |
| 6 | 340 | 163 S | 4 480 | 173 | 308 S | 4 570 | 228 | 182 S | 3 590 | 6 |
| 7 | 306 | 163 | 3 720 | 161 | 333 S | 5 060 | 229 | 165 S | 3 260 | 7 |
| 8 | 285 | 104 S | 2 420 | 174 | 376 S | 4 180 | 225 | 161 S | 3 130 | 8 |
| 9 | 334 | 337 S | 4 780 | 183 | 277 S | 3 900 | 214 | 157 S | 2 900 | 9 |
| 10 | 298 | 370 S | 4 850 | 159 | 287 | 3 870 | 202 | 148 S | 3 680 | 10 |
| 11 | 180 | 278 S | 4 580 | 155 | 282 | 3 510 | 187 | 161 S | 2 280 | 11 |
| 12 | 176 | 275 S | 4 230 | 152 | 280 S | 3 410 | 174 | 146 S | 2 190 | 12 |
| 13 | 187 | 268 | 3 440 | 149 | 269 S | 3 330 | 168 | 153 S | 2 280 | 13 |
| 14 | 189 | 286 S | 4 990 | 145 | 249 S | 3 130 | 183 | 146 S | 1 880 | 14 |
| 15 | 181 | 311 | 4 880 | 163 | 234 | 2 770 | 169 | 138 S | 1 850 | 15 |
| 16 | 148 | 318 | 3 980 | 140 | 210 | 2 540 | 149 | 136 S | 1 780 | 16 |
| 17 | 142 | 287 S | 3 660 | 162 | 215 | 2 840 | 142 | 137 S | 1 680 | 17 |
| 18 | 137 | 265 | 3 140 | 168 | 277 | 3 490 | 133 | 155 S | 1 780 | 18 |
| 19 | 136 | 236 S | 2 800 | 180 | 513 S | 7 080 | 128 | 179 S | 1 850 | 19 |
| 20 | 136 | 223 S | 2 830 | 207 | 884 S | 10 700 | 124 | 172 S | 1 840 | 20 |
| 21 | 136 | 231 | 2 780 | 255 | 503 | 11 100 | 122 | 182 S | 2 040 | 21 |
| 22 | 140 | 260 S | 3 140 | 287 | 461 | 10 900 | 128 | 173 S | 1 880 | 22 |
| 23 | 143 | 290 S | 3 580 | 314 | 463 | 10 900 | 134 | 162 S | 2 110 | 23 |
| 24 | 147 | 274 S | 3 480 | 338 | 382 S | 11 100 | 148 | 200 S | 2 580 | 24 |
| 25 | 152 | 265 S | 3 480 | 337 | 395 S | 4 590 | 159 | 184 S | 2 730 | 25 |
| 26 | 154 | 277 | 3 880 | 321 | 326 S | 5 270 | 159 | 191 S | 2 820 | 26 |
| 27 | 159 | 295 S | 4 080 | 303 | 173 S | 4 630 | 150 | 178 S | 2 310 | 27 |
| 28 | 167 | 308 S | 4 420 | 284 | 186 S | 3 930 | 138 | 161 S | 1 920 | 28 |
| 29 | 176 | 307 S | 4 840 | 271 | 159 S | 3 720 | 128 | 136 S | 1 520 | 29 |
| 30 | 182 | 438 S | 6 640 | 248 | 182 S | 3 850 | 130 | 116 S | 1 300 | 30 |
| 31 | 185 | 481 | 7 370 | 230 | 170 S | 3 230 | | | | 31 |
| TOTAL | 6 471 | | 133 770 | 6 447 | | 168 310 | 4 977 | | 70 430 | TOTAL |

| DAY | OCT DAILY DISCHARGE ($m^3/s$) | OCT MEAN CONCENTRATION (mg/L) | OCT DAILY LOAD (t) | NOV DAILY DISCHARGE ($m^3/s$) | NOV MEAN CONCENTRATION (mg/L) | NOV DAILY LOAD (t) | DEC DAILY DISCHARGE ($m^3/s$) | DEC MEAN CONCENTRATION (mg/L) | DEC DAILY LOAD (t) | DAY |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 118 | 103 S | 1 030 | 117 | 51 S | 518 | 59.2 S | 14 | 71.6 | 1 |
| 2 | 114 | 86 S | 847 | 116 | 47 S | 471 | 60.0 S | 14 | 72.6 | 2 |
| 3 | 111 | 81 S | 777 | 112 | 41 S | 397 | 59.7 S | 13 | 66.2 | 3 |
| 4 | 108 | 83 S | 782 | 110 | 35 S | 342 | 61.5 S | 13 | 63.6 | 4 |
| 5 | 107 | 88 S | 818 | 107 | 42 S | 386 | 61.5 S | 11 S | 58.4 | 5 |
| 6 | 105 | 91 S | 826 | 105 | 45 S | 408 | 62.3 S | 11 | 59.2 | 6 |
| 7 | 103 | 80 S | 713 | 103 | 43 S | 383 | 62.4 S | 11 | 59.3 | 7 |
| 8 | 103 | 97 S | 883 | 101 | 47 S | 410 | 62.2 S | 11 | 59.1 | 8 |
| 9 | 101 | 108 S | 951 | 98.6 | 40 S | 336 | 61.7 S | 11 | 58.6 | 9 |
| 10 | 99.5 | 95 S | 908 | 95.4 | 27 S | 223 | 61.0 S | 11 | 58.0 | 10 |
| 11 | 97.9 | 80 S | 677 | 85.5 | 27 | 199 | 60.3 S | 11 | 57.3 | 11 |
| 12 | 105 | 75 S | 680 | 71.2 | 27 | 166 | 59.7 S | 11 | 56.7 | 12 |
| 13 | 127 | 68 S | 986 | 71.7 S | 26 | 161 | 59.5 S | 10 | 51.4 | 13 |
| 14 | 183 | 112 S | 1 680 | 74.3 S | 26 | 167 | 59.4 S | 10 | 51.3 | 14 |
| 15 | 187 | 138 S | 1 850 | 87.5 S | 26 S | 183 | 59.6 S | 11 | 56.6 | 15 |
| 16 | 171 | 110 S | 1 820 | 82.7 S | 25 | 138 | 59.8 S | 10 | 51.7 | 16 |
| 17 | 168 | 84 S | 1 330 | 81.7 S | 25 | 133 | 60.1 S | 10 | 51.8 | 17 |
| 18 | 161 | 71 S | 988 | 83.8 S | 24 | 132 | 60.2 S | 11 | 57.2 | 18 |
| 19 | 156 | 66 S | 890 | 70.8 S | 23 | 141 | 60.0 S | 11 | 57.0 | 19 |
| 20 | 151 | 63 S | 832 | 68.4 S | 22 | 133 | 59.8 S | 11 | 56.8 | 20 |
| 21 | 145 | 82 S | 777 | 67.0 S | 21 | 122 | 59.4 S | 11 | 56.5 | 21 |
| 22 | 141 | 85 S | 782 | 67.4 S | 21 | 122 | 58.9 S | 11 | 56.0 | 22 |
| 23 | 136 | 73 S | 670 | 67.6 S | 20 | 117 | 58.7 S | 12 | 60.9 | 23 |
| 24 | 136 | 75 S | 861 | 68.3 S | 20 | 118 | 58.4 S | 13 | 60.5 | 24 |
| 25 | 135 | 80 S | 805 | 63.5 S | 20 | 110 | 58.0 S | 11 | 55.1 | 25 |
| 26 | 133 | 86 S | 788 | 61.0 S | 18 | 100 | 57.5 S | 10 | 49.7 | 26 |
| 27 | 132 | 84 S | 730 | 57.6 S | 18 | 88.8 | 56.3 S | 10 | 48.2 | 27 |
| 28 | 129 | 87 S | 835 | 56.5 S | 17 | 83.8 | 55.3 S | 10 | 46.6 | 28 |
| 29 | 125 | 81 S | 889 | 57.8 S | 18 | 70.8 | 55.6 S | 10 | 48.2 | 29 |
| 30 | 122 | 84 S | 875 | 58.4 S | 18 | 75.7 | 55.6 S | 10 | 46.0 | 30 |
| 31 | 118 | 86 S | 891 | | | | 55.2 S | 11 | 52.5 | 31 |
| TOTAL | 3 878.4 | | 27 907 | 3 385.2 | | 6 405.1 | 1 841.6 | | 1 781.9 | TOTAL |

S - ICE CONDITIONS

S - SAMPLE(S) COLLECTED THIS DAY

MANITOBA

RED RIVER AT EMERSON - STATION NO. 05OC001

INSTANTANEOUS SUSPENDED SEDIMENT FOR 1985

| DATE | TIME | WATER TEMP. (C) | INSTANT. DISCHARGE ($m^3/s$) | | SINGLE SAMPLING VERTICAL (m) | | TYPE OF SAMPLER | INSTANT. CONCENT. (mg/L) | | DISSOLVED SOLIDS (mg/L) | PERCENT FINER THAN INDICATED SIZE IN MILLIMETRES .002 | .004 | .008 | .016 | .031 | .062 | .125 | .250 | .500 | 1.00 | 2.00 | PERCENT SAND | SILT | CLAY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN 08 | 14:00 | 0.5 | 34.8 | E | 30.0 | X | DH48 | 11 | | 473 | | | | | | | | | | | | | | |
| FEB 06 | 12:45 | 0.5 | 33.0 | E | 37 | O X | DH48 | 13 | | 383 | | | | | | | | | | | | | | |
| FEB 27 | 12:00 | 0.5 | 34.3 | E | M/B | X | DH48 | 11 | | 339 | | | | | | | | | | | | | | |
| MAR 22 | 10:00 | 0.5 | 312 | | 131 | | DH59 | 184 | | 309 | | | | | | | | | | | | | | |
| MAR 22 | 12:30 | 0.5 | 76.1 | E | 104 | N | D48 | 208 | | 307 | | | | | | | | | | | | | | |
| MAR 22 | 12:35 | 0.5 | 83.4 | E | 116 | N | D48 | 191 | | 305 | | | | | | | | | | | | | | |
| MAR 22 | 12:40 | 0.5 | 86.2 | E | 121 | N | D48 | 177 | | 303 | | | | | | | | | | | | | | |
| MAR 22 | 12:45 | 0.5 | 86.1 | E | 143 | N | D48 | 184 | | 301 | | | | | | | | | | | | | | |
| MAR 22 | 12:50 | 0.5 | 90.6 | E | 157 | N | D48 | 228 | | 306 | | | | | | | | | | | | | | |
| MAR 24 | 18:00 | 1.0 | 378 | | 131 | | DH59 | 264 | | | | | | | | | | | | | | | | |
| MAR 24 | 18:01 | 1.0 | 378 | | 131 | | DH59 | 210 | | | | | | | | | | | | | | | | |
| MAR 24 | 18:02 | 1.0 | 378 | | 131 | | DH59 | 204 | | | | | | | | | | | | | | | | |
| MAR 24 | 18:03 | 1.0 | 378 | | 131 | | DH59 | 218 | | | | | | | | | | | | | | | | |
| MAR 27 | 11:15 | 0.5 | 482 | | 136 | | DH59 | 373 | | 289 | | | | | | | | | | | | | | |
| APR 03 | 12:40 | 1.0 | 80.4 | | 155 | N | D48 | 239 | | | | | | | | | | | | | | | | |
| APR 03 | 12:45 | 1.0 | 77.2 | | 143 | N | D48 | 238 | | | | | | | | | | | | | | | | |
| APR 03 | 12:50 | 1.0 | 87.0 | | 131 | N | D48 | 241 | | 312 | | | | | | | | | | | | | | |
| APR 03 | 12:55 | 1.0 | 82.3 | | 118 | N | D48 | 234 | | | | | | | | | | | | | | | | |
| APR 03 | 13:00 | 1.0 | 102 | | 102 | N | D48 | 246 | | | | | | | | | | | | | | | | |
| APR 06 | 09:00 | 3.0 | 282 | N | 131 | | DH59 | 99 | A | | | | | | | | | | | | | | | |
| APR 06 | 09:01 | 3.0 | 282 | N | 131 | | DH59 | 227 | | | | | | | | | | | | | | | | |
| APR 06 | 10:50 | 3.0 | 246 | N | 131 | | DH59 | 490 | | | | | | | | | | | | | | | | |
| APR 06 | 11:00 | 3.0 | 72.7 | | 108 | N | D48 | 458 | | 341 | 45 | 51 | 77 | 84 | 94 | 98 | 100 | | | | 3 | 47 | 51 |
| APR 06 | 11:05 | 3.0 | 83.4 | | 122 | N | D48 | 447 | | 334 | 38 | 52 | 72 | 86 | 95 | 97 | 100 | | | | 3 | 45 | 52 |
| APR 06 | 11:10 | 3.0 | 38.4 | | 131 | N | D48 | 448 | | 331 | 37 | 50 | 72 | 84 | 97 | 97 | 99 | 100 | | | 3 | 47 | 50 |
| APR 06 | 11:15 | 3.0 | 84.1 | | 143 | N | D48 | 488 | | 334 | 34 | 51 | 72 | 89 | 96 | 98 | 100 | | | | 2 | 47 | 51 |
| APR 06 | 11:20 | 3.0 | 38.4 | | 157 | N | D48 | 480 | | 332 | 38 | 50 | 74 | 87 | 96 | 97 | 99 | 100 | | | 3 | 47 | 50 |
| APR 14 | 18:00 | 8.0 | 181 | N | 131 | | DH59 | 381 | | 381 | 34 | 52 | 71 | 88 | 96 | 98 | 99 | 100 | | | 2 | 46 | 52 |
| APR 14 | 18:01 | 8.0 | 181 | N | 131 | | DH59 | 384 | | | | | | | | | | | | | | | | |
| APR 14 | 18:02 | 8.0 | 181 | N | 131 | | DH59 | 417 | | | | | | | | | | | | | | | | |
| APR 15 | 10:30 | 8.0 | 48.3 | | 107 | N | DH59 | 598 | | 381 | | | | | | | | | | | | | | |
| APR 15 | 10:35 | 8.0 | 40.4 | | 122 | N | DH59 | 585 | | 342 | | | | | | | | | | | | | | |
| APR 15 | 10:40 | 8.0 | 24.6 | | 131 | N | DH59 | 560 | | 348 | | | | | | | | | | | | | | |
| APR 15 | 10:45 | 8.0 | 42.8 | | 142 | N | DH59 | 581 | | 338 | | | | | | | | | | | | | | |
| APR 15 | 10:50 | 8.0 | 19.5 | | 157 | N | DH59 | 572 | | | | | | | | | | | | | | | | |
| APR 20 | 12:00 | 12.0 | 182 | N | 131 | | DH59 | 219 | | 424 | | | | | | | | | | | | | | |
| APR 25 | 12:00 | 13.0 | 128 | N | 131 | | DH59 | 561 | | | | | | | | | | | | | | | | |
| APR 30 | 12:00 | 14.0 | 165 | N | 131 | | DH59 | 904 | | 429 | | | | | | | | | | | | | | |
| MAY 06 | 11:15 | 14.0 | 38.4 | | 107 | N | DH59 | 388 | | 422 | | | | | | | | | | | | | | |
| MAY 06 | 11:20 | 14.0 | 27.6 | | 122 | N | DH59 | 288 | | 426 | | | | | | | | | | | | | | |
| MAY 06 | 11:25 | 14.0 | 19.5 | | 131 | N | DH59 | 256 | | 423 | | | | | | | | | | | | | | |
| MAY 06 | 11:30 | 14.0 | 30.0 | | 143 | N | DH59 | 253 | | 417 | | | | | | | | | | | | | | |
| MAY 06 | 11:35 | 14.0 | 11.3 | | 155 | N | DH59 | 288 | | 433 | | | | | | | | | | | | | | |
| MAY 06 | 12:00E | 16.0 | 121 | N | 131 | | DH59 | 350 | | 386 | 35 | 52 | 77 | 84 | 94 | 99 | 100 | | | | 1 | 37 | 62 |
| MAY 10 | 12:00E | 16.0 | 116 | N | 131 | | DH59 | 448 | | | | | | | | | | | | | | | | |
| MAY 13 | 20:00 | 16.0 | 140 | N | 131 | | DH59 | 324 | | 386 | | | | | | | | | | | | | | |
| MAY 14 | 20:00 | 16.0 | 165 | N | 131 | | DH59 | 311 | | | | | | | | | | | | | | | | |
| MAY 15 | 16:00 | 16.0 | 268 | N | 131 | | DH59 | 443 | | | | | | | | | | | | | | | | |
| MAY 16 | 16:00 | 16.0 | 330 | N | 131 | | DH59 | 377 | | | | | | | | | | | | | | | | |
| MAY 17 | 11:15 | 16.0 | 104 | | 105 | N | DH59 | 1930 | | 209 | 17 | 32 | 57 | 83 | 96 | 99 | 100 | | | | 1 | 47 | 52 |
| MAY 17 | 11:20 | 16.0 | 80.4 | | 122 | N | DH59 | 1890 | | 184 | 18 | 39 | 66 | 84 | 95 | 98 | 99 | 99 | 100 | | 2 | 49 | 49 |
| MAY 17 | 11:25 | 16.0 | 54.2 | | 131 | N | DH59 | 1880 | | 208 | 21 | 39 | 66 | 84 | 93 | 99 | 99 | 100 | | | 1 | 48 | 51 |
| MAY 17 | 11:30 | 16.0 | 59.8 | | 140 | N | DH59 | 1870 | | 219 | 18 | 38 | 64 | 84 | 96 | 98 | 100 | | | | 1 | 48 | 51 |
| MAY 17 | 11:35 | 16.0 | 74.9 | | 149 | N | DH59 | 1870 | | 211 | 33 | 48 | 63 | 86 | 98 | 99 | 99 | 100 | | | 1 | 31 | 68 |
| MAY 18 | 18:00 | 18.0 | 403 | N | 131 | | DH59 | 288 | A | | | | | | | | | | | | | | | |
| MAY 20 | 21:00 | 18.0 | 448 | N | 131 | | DH59 | 305 | A | 311 | | | | | | | | | | | | | | |
| MAY 20 | 22:00 | 18.0 | 445 | N | 131 | | DH59 | 418 | | | | | | | | | | | | | | | | |
| MAY 22 | 11:15 | 17.0 | 138 | | 105 | N | DH59 | 382 | | 383 | 46 | 71 | 86 | 94 | 97 | 98 | 99 | 100 | | | 2 | 37 | 71 |
| MAY 22 | 11:20 | 17.0 | 86.1 | | 122 | N | DH59 | 380 | | 310 | 37 | 37 | 88 | 100 | | | | | | | 0 | 63 | 37 |
| MAY 22 | 11:25 | 17.0 | 71.5 | | 131 | N | DH59 | 388 | | 381 | 43 | 64 | 82 | 91 | 95 | 97 | 97 | 100 | | | 3 | 33 | 64 |
| MAY 22 | 11:30 | 17.0 | 72.5 | | 140 | N | DH59 | 388 | | 383 | 48 | 65 | 84 | 93 | 97 | 98 | 99 | 100 | | | 2 | 33 | 65 |
| MAY 22 | 11:35 | 17.0 | 83.5 | | 148 | N | DH59 | 407 | | 311 | 48 | 67 | 83 | 92 | 95 | 97 | 99 | 100 | | | 3 | 30 | 67 |
| MAY 27 | 09:00 | 17.0 | 325 | N | 131 | | DH59 | 187 | | 458 | | | | | | | | | | | | | | |
| MAY 28 | 10:00 | 17.0 | 70.0 | | 101 | N | D48 | 178 | | 462 | | | | | | | | | | | | | | |
| MAY 28 | 10:05 | 17.0 | 84.1 | | 119 | N | D48 | 173 | | 466 | | | | | | | | | | | | | | |
| MAY 28 | 10:10 | 17.0 | 81.4 | | 131 | N | D48 | 171 | | 461 | | | | | | | | | | | | | | |
| MAY 28 | 10:15 | 17.0 | 80.6 | | 140 | N | D48 | 170 | | 480 | | | | | | | | | | | | | | |
| JUN 26 | 09:30 | 18.0 | 39.4 | | 107 | N | DH59 | 346 | | 431 | | | | | | | | | | | | | | |
| JUN 26 | 09:35 | 18.0 | 26.3 | | 122 | N | DH59 | 363 | | 430 | | | | | | | | | | | | | | |
| JUN 26 | 09:40 | 18.0 | 28.1 | | 131 | N | DH59 | 377 | | 430 | | | | | | | | | | | | | | |
| JUN 26 | 09:45 | 18.0 | 29.9 | | 143 | N | DH59 | 382 | | 422 | | | | | | | | | | | | | | |
| JUN 26 | 09:50 | 18.0 | 20.0 | | 155 | N | DH59 | 349 | | 420 | | | | | | | | | | | | | | |
| JUL 03 | 12:00E | 22.0 | 380 | N | 131 | | DH59 | 187 | | | | | | | | | | | | | | | | |
| JUL 04 | 12:00E | 21.0 | 381 | N | 131 | | DH59 | 180 | | | | | | | | | | | | | | | | |
| JUL 05 | 11:00 | 21.0 | 385 | N | 131 | | DH59 | 224 | A | | | | | | | | | | | | | | | |
| JUL 05 | 11:35 | 22.0 | 71.6 | | 94 | O N | D48 | 184 | | 333 | | | | | | | | | | | | | | |
| JUL 05 | 11:40 | 22.0 | 83.5 | | 116 | N | D48 | 184 | | 314 | | | | | | | | | | | | | | |
| JUL 05 | 11:45 | 22.0 | 78.1 | | 131 | N | D48 | 180 | | 316 | | | | | | | | | | | | | | |
| JUL 05 | 11:50 | 22.0 | 72.3 | | 140 | N | D48 | 158 | | 300 | | | | | | | | | | | | | | |
| JUL 05 | 11:55 | 22.0 | 63.7 | | 157 | N | D48 | 180 | | 295 | | | | | | | | | | | | | | |
| JUL 08 | 19:30 | 24.0 | 340 | N | 131 | | DH59 | 140 | | | | | | | | | | | | | | | | |
| JUL 08 | 21:00 | 24.0 | 288 | N | 131 | | DH59 | 140 | | | | | | | | | | | | | | | | |
| JUL 09 | 12:00 | 24.0 | 234 | N | 131 | | DH59 | 245 | | | | | | | | | | | | | | | | |
| JUL 10 | 21:30 | 23.0 | 208 | N | 131 | | DH59 | 267 | | | | | | | | | | | | | | | | |
| JUL 11 | 21:30 | 23.0 | 190 | N | 131 | | DH59 | 263 | | | | | | | | | | | | | | | | |
| JUL 12 | 21:00 | 24.0 | 178 | N | 131 | | DH59 | 282 | | 367 | | | | | | | | | | | | | | |
| JUL 14 | 08:00 | 23.0 | 188 | N | 131 | | DH59 | 298 | | | | | | | | | | | | | | | | |
| JUL 17 | 21:00 | 23.0 | 142 | N | 131 | | DH59 | 284 | | | | | | | | | | | | | | | | |
| JUL 18 | 00:00 | 23.0 | 136 | N | 131 | | DH59 | 240 | | 363 | | | | | | | | | | | | | | |
| JUL 20 | 21:20 | 23.0 | 138 | N | 131 | | DH59 | 226 | | | | | | | | | | | | | | | | |
| JUL 22 | 21:20 | 23.0 | 140 | N | 131 | | DH59 | 285 | | | | | | | | | | | | | | | | |
| JUL 23 | 21:30 | 22.0 | 143 | N | 131 | | DH59 | 285 | | | | | | | | | | | | | | | | |
| JUL 24 | 21:15 | 22.0 | 147 | N | 131 | | DH59 | 263 | | | | | | | | | | | | | | | | |
| JUL 25 | 21:00 | 22.0 | 152 | N | 131 | | DH59 | 286 | | | | | | | | | | | | | | | | |
| JUL 27 | 21:00 | 22.0 | 158 | N | 131 | | DH59 | 303 | | 325 | | | | | | | | | | | | | | |
| JUL 28 | 08:50 | 23.0 | 187 | N | 131 | | DH59 | 307 | | | | | | | | | | | | | | | | |
| JUL 29 | 18:30 | 22.0 | 178 | N | 131 | | DH59 | 306 | | | | | | | | | | | | | | | | |
| JUL 30 | 18:30 | 22.0 | 182 | N | 131 | | DH59 | 488 | | | | | | | | | | | | | | | | |
| AUG 01 | 20:30 | 23.0 | 188 | N | 131 | | DH59 | 360 | | | | | | | | | | | | | | | | |
| AUG 02 | 21:00 | 23.0 | 183 | N | 131 | | DH59 | 365 | | | | | | | | | | | | | | | | |
| AUG 04 | 21:15 | 22.0 | 171 | N | 131 | | DH59 | 339 | | | | | | | | | | | | | | | | |
| AUG 05 | 20:00 | 23.0 | 168 | N | 131 | | DH59 | 291 | | 307 | | | | | | | | | | | | | | |
| AUG 08 | 20:30 | 22.0 | 173 | N | 131 | | DH59 | 355 | | | | | | | | | | | | | | | | |

NOTE SINGLE VERTICAL LOCATED AT 131 METRES FOR 1985

TIME SYMBOL E - ESTIMATED

DISCHARGE SYMBOL(S) B - ICE CONDITIONS N - DAILY MEAN W - DAILY MEAN, ICE CONDITIONS

CONCENTRATION SYMBOL(S) A - CLASSIFIED AS AN ANOMALY

VERTICAL SYMBOL(S) X - NOT AT REGULAR SINGLE SAMPLE VERTICAL M - A SEDIMENT MEASUREMENT VERTICAL

CONTINUED

RED RIVER AT EMERSON - STATION NO. 05OC001 (CONTINUED)

INSTANTANEOUS SUSPENDED SEDIMENT FOR 1985

| DATE | TIME | WATER TEMP. (°C) | INSTANT. DISCHARGE ($m^3/s$) | | SINGLE VERTICAL SAMPLING (m) | | TYPE OF SAMPLER | INSTANT. CONCENT (mg/L) | | DISSOLVED SOLIDS (mg/L) | PERCENT FINER THAN INDICATED SIZE, IN MILLIMETRES .002 | .004 | .008 | .016 | .031 | .062 | .125 | .250 | .500 | 1.00 | 2.00 | PERCENT SAND | SILT | CLAY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AUG | 07 | 13:00 | 22.0 | 43.8 | | 100 | M DH59 | 302 | | 287 | | | | | | | | | | | | | | |
| AUG | 07 | 13:05 | 22.0 | 39.2 | | 120 | M DH59 | 319 | | 283 | | | | | | | | | | | | | | |
| AUG | 07 | 13:10 | 22.0 | 41.3 | | 122 | M DH59 | 311 | | 287 | | | | | | | | | | | | | | |
| AUG | 07 | 13:15 | 22.0 | 38.0 | | 144 | M DH59 | 308 | | 286 | | | | | | | | | | | | | | |
| AUG | 07 | 13:20 | 22.0 | 21.2 | | 180 | M DH59 | 337 | | 295 | | | | | | | | | | | | | | |
| AUG | 07 | 19:45 | 22.0 | 181 | M | 131 | DH59 | 288 | | | | | | | | | | | | | | | | |
| AUG | 08 | 20:30 | 23.0 | 174 | M | 131 | DH59 | 283 | | | | | | | | | | | | | | | | |
| AUG | 09 | 09:30 | 21.0 | 163 | M | 131 | DH59 | 277 | | | | | | | | | | | | | | | | |
| AUG | 12 | 19:00 | 20.0 | 162 | M | 131 | DH59 | 287 | | | | | | | | | | | | | | | | |
| AUG | 13 | 19:00 | 19.0 | 148 | M | 131 | DH59 | 260 | | | | | | | | | | | | | | | | |
| AUG | 14 | 21:00 | 19.0 | 146 | M | 131 | DH59 | 328 | | | | | | | | | | | | | | | | |
| AUG | 19 | 19:30 | 17.0 | 160 | M | 131 | DH59 | 590 | | 306 | 47 | 65 | 79 | 87 | 94 | 97 | 99 | 100 | | | 3 | 32 | 65 |
| AUG | 20 | 19:30 | 17.0 | 207 | M | 131 | DH59 | 554 | | | | | | | | | | | | | | | | |
| AUG | 24 | 19:30 | 16.0 | 335 | M | 131 | DH59 | 351 | | | | | | | | | | | | | | | | |
| AUG | 25 | 09:00 | 17.0 | 337 | M | 131 | DH59 | 288 | | | | | | | | | | | | | | | | |
| AUG | 26 | 20:00 | 18.0 | 321 | M | 131 | DH59 | 195 | | | | | | | | | | | | | | | | |
| AUG | 27 | 09:30 | 18.0 | 74.0 | | 98 | O M DA9 | 171 | | 301 | | | | | | | | | | | | | | |
| AUG | 27 | 09:35 | 18.0 | 87.1 | | 120 | M DA9 | 173 | | 300 | | | | | | | | | | | | | | |
| AUG | 27 | 09:40 | 18.0 | 89.9 | | 132 | M DA9 | 166 | | 306 | | | | | | | | | | | | | | |
| AUG | 27 | 09:45 | 18.0 | 80.2 | | 144 | M DA9 | 169 | | 305 | | | | | | | | | | | | | | |
| AUG | 27 | 09:50 | 18.0 | 80.7 | | 156 | M DA9 | 170 | | 300 | | | | | | | | | | | | | | |
| AUG | 27 | 20:15 | 18.0 | 303 | M | 131 | DH59 | 158 | | | | | | | | | | | | | | | | |
| AUG | 28 | 21:00 | 17.0 | 288 | M | 131 | DH59 | 146 | | | | | | | | | | | | | | | | |
| AUG | 28 | 20:00 | 18.0 | 271 | M | 131 | DH59 | 185 | | | | | | | | | | | | | | | | |
| AUG | 30 | 19:00 | 18.0 | 245 | M | 131 | DH59 | 180 | | | | | | | | | | | | | | | | |
| AUG | 31 | 09:00 | 16.0 | 220 | M | 131 | DH59 | 168 | | | | | | | | | | | | | | | | |
| SEP | 01 | 09:00 | 16.0 | 198 | M | 131 | DH59 | 159 | | | | | | | | | | | | | | | | |
| SEP | 02 | 09:00 | 17.0 | 183 | M | 131 | DH59 | 169 | | | | | | | | | | | | | | | | |
| SEP | 03 | 17:00 | 17.0 | 183 | M | 131 | DH59 | 159 | | | | | | | | | | | | | | | | |
| SEP | 04 | 08:00 | 17.0 | 194 | M | 131 | DH59 | 148 | | 342 | | | | | | | | | | | | | | |
| SEP | 05 | 08:00 | 16.0 | 217 | M | 131 | DH59 | 201 | | | | | | | | | | | | | | | | |
| SEP | 06 | 08:00 | 17.0 | 226 | M | 131 | DH59 | 187 | | | | | | | | | | | | | | | | |
| SEP | 07 | 08:00 | 16.0 | 228 | M | 131 | DH59 | 164 | | | | | | | | | | | | | | | | |
| SEP | 08 | 08:00 | 16.0 | 225 | M | 131 | DH59 | 160 | | | | | | | | | | | | | | | | |
| SEP | 09 | 08:00E | 16.0 | 214 | M | 131 | DH59 | 158 | | | | | | | | | | | | | | | | |
| SEP | 10 | 08:00 | 15.0 | 202 | M | 131 | DH59 | 148 | | | | | | | | | | | | | | | | |
| SEP | 11 | 08:00 | 15.0 | 187 | M | 131 | DH59 | 141 | | 344 | | | | | | | | | | | | | | |
| SEP | 12 | 08:00 | 15.0 | 174 | M | 131 | DH59 | 142 | | | | | | | | | | | | | | | | |
| SEP | 13 | 08:00 | 15.0 | 166 | M | 131 | DH59 | 169 | | | | | | | | | | | | | | | | |
| SEP | 14 | 08:00 | 15.0 | 159 | M | 131 | DH59 | 147 | | | | | | | | | | | | | | | | |
| SEP | 15 | 08:00 | 15.0 | 155 | M | 131 | DH59 | 136 | | | | | | | | | | | | | | | | |
| SEP | 16 | 08:00 | 15.0 | 149 | M | 131 | DH59 | 135 | | | | | | | | | | | | | | | | |
| SEP | 17 | 08:00 | 15.0 | 142 | M | 131 | DH59 | 134 | | | | | | | | | | | | | | | | |
| SEP | 18 | 08:00 | 15.0 | 133 | M | 131 | DH59 | 150 | | 348 | | | | | | | | | | | | | | |
| SEP | 19 | 20:00 | 15.0 | 128 | M | 131 | DH59 | 184 | | | | | | | | | | | | | | | | |
| SEP | 20 | 15:00 | 13.0 | 124 | M | 131 | DH59 | 169 | A | | | | | | | | | | | | | | | |
| SEP | 21 | 15:00 | 13.0 | 123 | M | 131 | DH59 | 192 | | | | | | | | | | | | | | | | |
| SEP | 22 | 08:00 | 13.0 | 128 | M | 131 | DH59 | 173 | | | | | | | | | | | | | | | | |
| SEP | 23 | 08:00 | 12.0 | 134 | M | 131 | DH59 | 178 | | | | | | | | | | | | | | | | |
| SEP | 24 | 08:00 | 11.0 | 148 | M | 131 | DH59 | 203 | | | | | | | | | | | | | | | | |
| SEP | 24 | 10:00 | 10.0 | 36.1 | | 104 | M DH59 | 201 | | 327 | | | | | | | | | | | | | | |
| SEP | 24 | 10:05 | 10.0 | 26.8 | | 120 | M DH59 | 208 | | 333 | | | | | | | | | | | | | | |
| SEP | 24 | 10:10 | 10.0 | 33.5 | | 132 | M DH59 | 201 | | 332 | | | | | | | | | | | | | | |
| SEP | 24 | 10:15 | 10.0 | 32.2 | | 146 | M DH59 | 201 | | 331 | | | | | | | | | | | | | | |
| SEP | 24 | 10:20 | 10.0 | 12.8 | | 160 | M DH59 | 198 | | 330 | | | | | | | | | | | | | | |
| SEP | 25 | 08:00 | 10.0 | 188 | M | 131 | DH59 | 198 | | | | | | | | | | | | | | | | |
| SEP | 26 | 08:00 | 10.0 | 188 | M | 131 | DH59 | 192 | | | | | | | | | | | | | | | | |
| SEP | 27 | 08:00 | 10.0 | 150 | M | 131 | DH59 | 180 | | | | | | | | | | | | | | | | |
| SEP | 28 | 08:00 | 9.0 | 138 | M | 131 | DH59 | 184 | | | | | | | | | | | | | | | | |
| SEP | 29 | 08:00 | 8.0 | 128 | M | 131 | DH59 | 143 | | | | | | | | | | | | | | | | |
| SEP | 30 | 08:00 | 8.0 | 120 | M | 131 | DH59 | 119 | | 389 | | | | | | | | | | | | | | |
| OCT | 01 | 08:00 | 8.0 | 116 | M | 131 | DH59 | 107 | | | | | | | | | | | | | | | | |
| OCT | 02 | 08:00 | 8.0 | 114 | M | 131 | DH59 | 88 | | | | | | | | | | | | | | | | |
| OCT | 03 | 08:00 | 8.0 | 111 | M | 131 | DH59 | 83 | | | | | | | | | | | | | | | | |
| OCT | 04 | 08:00 | 8.0 | 109 | M | 131 | DH59 | 74 | | | | | | | | | | | | | | | | |
| OCT | 05 | 08:00 | 8.0 | 107 | M | 131 | DH59 | 100 | | | | | | | | | | | | | | | | |
| OCT | 06 | 08:00 | 7.0 | 106 | M | 131 | DH59 | 98 | | | | | | | | | | | | | | | | |
| OCT | 07 | 08:00 | 7.0 | 103 | M | 131 | DH59 | 80 | | 386 | | | | | | | | | | | | | | |
| OCT | 08 | 14:00 | 8.0 | 103 | M | 131 | DH59 | 100 | | | | | | | | | | | | | | | | |
| OCT | 09 | 18:00 | 8.0 | 101 | M | 131 | DH59 | 111 | | | | | | | | | | | | | | | | |
| OCT | 10 | 08:00 | 8.0 | 98.5 | M | 131 | DH59 | 99 | | | | | | | | | | | | | | | | |
| OCT | 11 | 08:00 | 8.0 | 97.9 | M | 131 | DH59 | 82 | | | | | | | | | | | | | | | | |
| OCT | 12 | 08:00 | 8.0 | 105 | M | 131 | DH59 | 72 | | | | | | | | | | | | | | | | |
| OCT | 13 | 08:00 | 7.0 | 127 | M | 131 | DH59 | 84 | | | | | | | | | | | | | | | | |
| OCT | 14 | 08:00 | 7.0 | 153 | M | 131 | DH59 | 108 | | 353 | | | | | | | | | | | | | | |
| OCT | 15 | 08:00 | 8.0 | 167 | M | 131 | DH59 | 127 | | | | | | | | | | | | | | | | |
| OCT | 16 | 08:00 | 8.0 | 171 | M | 131 | DH59 | 113 | | | | | | | | | | | | | | | | |
| OCT | 17 | 08:00 | 8.0 | 168 | M | 131 | DH59 | 85 | | | | | | | | | | | | | | | | |
| OCT | 18 | 08:00 | 8.0 | 161 | M | 131 | DH59 | 72 | | | | | | | | | | | | | | | | |
| OCT | 19 | 08:00 | 8.0 | 168 | M | 131 | DH59 | 66 | | | | | | | | | | | | | | | | |
| OCT | 20 | 08:00 | 8.0 | 161 | M | 131 | DH59 | 62 | | | | | | | | | | | | | | | | |
| OCT | 21 | 08:00 | 7.0 | 148 | M | 131 | DH59 | 60 | | 476 | | | | | | | | | | | | | | |
| OCT | 22 | 08:00 | 8.0 | 141 | M | 131 | DH59 | 64 | | | | | | | | | | | | | | | | |
| OCT | 23 | 04:00 | 8.0 | 136 | M | 131 | DH59 | 72 | | | | | | | | | | | | | | | | |
| OCT | 23 | 11:30 | 8.0 | 28.0 | | 100 | M DH59 | 77 | | 484 | | | | | | | | | | | | | | |
| OCT | 23 | 11:35 | 8.0 | 25.9 | | 116 | M DH59 | 77 | | 487 | | | | | | | | | | | | | | |
| OCT | 23 | 11:40 | 8.0 | 28.3 | | 132 | M DH59 | 76 | | 483 | | | | | | | | | | | | | | |
| OCT | 23 | 11:45 | 8.0 | 34.6 | | 148 | M DH59 | 73 | | 502 | | | | | | | | | | | | | | |
| OCT | 23 | 11:50 | 8.0 | 0.72 | | 164 | M DH59 | 73 | | 500 | | | | | | | | | | | | | | |
| OCT | 24 | 08:00 | 8.0 | 136 | M | 131 | DH59 | 76 | | | | | | | | | | | | | | | | |
| OCT | 25 | 08:00 | 8.0 | 135 | M | 131 | DH59 | 70 | | | | | | | | | | | | | | | | |
| OCT | 26 | 08:00 | 8.0 | 133 | M | 131 | DH59 | 86 | | | | | | | | | | | | | | | | |
| OCT | 27 | 08:00 | 8.0 | 132 | M | 131 | DH59 | 85 | | | | | | | | | | | | | | | | |
| OCT | 28 | 08:00 | 7.0 | 128 | M | 131 | DH59 | 55 | | | | | | | | | | | | | | | | |
| OCT | 29 | 08:00 | 7.0 | 125 | M | 131 | DH59 | 85 | | | | | | | | | | | | | | | | |
| OCT | 30 | 08:00 | 7.0 | 122 | M | 131 | DH59 | 64 | | | | | | | | | | | | | | | | |
| OCT | 31 | 08:00 | 7.0 | 118 | M | 131 | DH59 | 59 | | | | | | | | | | | | | | | | |
| NOV | 01 | 08:00 | 6.0 | 117 | M | 131 | DH59 | 51 | | | | | | | | | | | | | | | | |
| NOV | 02 | 08:00 | 6.0 | 116 | M | 131 | DH59 | 46 | | | | | | | | | | | | | | | | |
| NOV | 03 | 08:00 | 5.0 | 112 | M | 131 | DH59 | 42 | | | | | | | | | | | | | | | | |
| NOV | 04 | 08:00 | 5.0 | 110 | M | 131 | DH59 | 36 | | | | | | | | | | | | | | | | |
| NOV | 05 | 08:00 | 5.0 | 107 | M | 131 | DH59 | 38 | | | | | | | | | | | | | | | | |
| NOV | 06 | 08:00 | 5.0 | 105 | M | 131 | DH59 | 46 | | 406 | | | | | | | | | | | | | | |

NOTE SINGLE VERTICAL LOCATED AT 131 METRES FOR 1985

TIME SYMBOL E - ESTIMATED
DISCHARGE SYMBOL(S) M - DAILY MEAN
CONCENTRATION SYMBOL(S) A - CLASSIFIED AS AN ANOMALY
VERTICAL SYMBOL(S) M - A SEDIMENT MEASUREMENT VERTICAL

CONTINUED

RED RIVER AT EMERSON - STATION NO 05OC001 (CONTINUED)

INSTANTANEOUS SUSPENDED SEDIMENT FOR 1985

| DATE | TIME | WATER TEMP. (°C) | INSTANT DISCHARGE ($m^3/s$) | | SINGLE VERTICAL SAMPLING (m) | TYPE OF SAMPLER | INSTANT CONCENT (mg/L) | DISSOLVED SOLIDS (mg/L) | PERCENT FINER THAN INDICATED SIZE, IN MILLIMETRES .002 | .004 | .008 | .016 | .031 | .062 | .125 | .250 | .500 | 1.00 | 2.00 | PERCENT SAND | SILT | CLAY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NOV 07 | 08:00 | 5.0 | 103 | N | 131 | DH59 | 43 | | | | | | | | | | | | | | | |
| NOV 08 | 08:00 | 5.0 | 101 | N | 131 | DH59 | 47 | 408 | | | | | | | | | | | | | | |
| NOV 09 | 08:00 | 5.0 | 96.5 | N | 131 | DH59 | 43 | | | | | | | | | | | | | | | |
| NOV 10 | 08:00 | 5.0 | 95.4 | N | 131 | DH59 | 36 | | | | | | | | | | | | | | | |
| NOV 15 | 16:00 | 0.0 | 57.5 | W | 131 | DH59 | 24 | 410 | | | | | | | | | | | | | | |
| DEC 06 | 12:30 | 0.5 | 9.62 | S | 11.0 Z | DH59 | 9 | 415 | | | | | | | | | | | | | | |
| DEC 06 | 12:35 | 0.5 | 12.3 | S | 26.0 Z | DH59 | 13 | 432 | | | | | | | | | | | | | | |
| DEC 06 | 12:40 | 0.5 | 11.6 | S | 35.0 Z | DH59 | 11 | 428 | | | | | | | | | | | | | | |
| DEC 06 | 12:45 | 0.5 | 10.9 | S | 47.0 Z | DH59 | 11 | 439 | | | | | | | | | | | | | | |
| DEC 06 | 12:50 | 0.5 | 10.4 | S | 63.0 Z | DH59 | 9 | 429 | | | | | | | | | | | | | | |

NOTE - SINGLE VERTICAL LOCATED AT 131 METRES FOR 1985

DISCHARGE SYMBOL(S): S - ICE CONDITIONS N - DAILY MEAN W - DAILY MEAN; ICE CONDITIONS
VERTICAL SYMBOL(S): Z - A SEDIMENT MEASUREMENT VERTICAL NOT AT THE REGULAR MEASUREMENT CROSS-SECTION

RED RIVER AT EMERSON - STATION NO 05OC001

HISTORICAL SEDIMENT DATA SUMMARY

| YEAR | PERIOD OF OPERATION SUMMARY (JFMAMJJASOND) | TYPE OF SAMPLING | SAMPLED CONCENTRATION MAXIMUM (mg/L) | | MINIMUM (mg/L) | | SUSPENDED SEDIMENT LOAD MAXIMUM DAILY (TONNES) | | TOTAL FOR PERIOD (TONNES) | SUMMARY JAN-DEC MEAN LOAD (TONNES) | HISTORICAL MEAN LOAD (TONNES) | STANDARD ERROR OF MEAN % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1955 | ---PC------- | MANUAL | 885 | APR 21 | 265 | MAY 10 | 35 300 | APR 23 | 585 000 | --- | --- | --- |
| 1961 | ---P-------- | MANUAL | 310 | APR 15 | 130 | APR 25 | 1 570 | APR 15 | 7 810 | --- | --- | --- |
| 1978 | CCCCCCCCCCCC | MANUAL | 733 | JUL 17 | 19 | FEB 05 | 55 100 | APR 11 * | 1 130 000 | 3 100 | 3 100 | --- |
| 1979 | CCCCCCCCCCCC | MANUAL | 523 | JUL 07 | 12 | JAN 23 | 45 800 | APR 26 | 1 500 000 * | 4 130 | 3 610 | 14.1 |
| 1980 | CCCCCCCCCCCC | MANUAL | 659 | APR 09 | 10 | FEB 13 | 33 400 | APR 05 | 388 000 | 1 010 | 2 740 | 33.4 |
| 1981 | CCCCCCCCCCCC | MANUAL | 1 580 | MAY 30 | 9 | JAN 15 | 22 000 | JUL 03 | 372 000 | 1 020 | 2 310 | 33.7 |
| 1982 | CCCCCCCCCCCC | MANUAL | 961 | JUN 09 | 8 | JAN 05 | 33 200 | APR 17 | 848 000 | 2 320 | 2 310 | 26.1 |
| 1983 | CCCCCCCCCCCC | MANUAL | 866 | JUN 18 | 5 | FEB 07 * | 23 300 | APR 09 | 752 000 | 2 080 | 2 280 | 21.6 |
| 1984 | CCCCCCCCCCCC | MANUAL | 851 | JUN 12 | 10 | JAN 05 | 32 700 | JUN 13 | 733 000 | 2 000 | 2 240 | 15.7 |
| 1985 | CCCCCCCCCCCC | MANUAL | 1 930 | MAY 17 * | 8 | DEC 05 | 54 000 | MAY 17 | 1 210 000 | 3 310 | 2 370 | 18.3 |

MANUAL - MANUAL SAMPLING

C - COMPLETE MONTH P - PARTIAL MONTH * - EXTREME FOR PERIOD OF RECORD